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Reduction of cost of the Naval Special Warfare Basic Underwater Demolition

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NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

REDUCTION OF COST OF THE NAVAL SPECIAL WARFARE BASIC UNDERWATER DEMOLITION / SEAL TRAINING COURSE

By

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March 1994

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REDUCTION OF COST OF THE NAVAL SPECIAL WARFARE BASIC UNDERWATER DEMOLITION / SEAL TRAINING COURSE

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Submitted in partial fulfillment
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ABSTRACT

Down-sizing of the military means reduction in operating budgets of most commands. Currently, the Basic Underwater Demolition / SEAL (BUD/S) training program has one of the highest attrition rates of any military school. Because of this high attrition rate there is potentially a great deal of monetary waste that could be saved in this program, both in students that do not successfully complete the program as well as those that graduate. The purpose of this study is to analyze in detail the BUD/S program, identify inefficiencies and associated potential savings and recommend future studies to expand on these savings. Topics discussed in this paper are:

- Determination of attrition rates and distributions for each dis-enrollment category.
- Arrival date and its effect on graduation rate.
- Class convening date and its effect on graduation rate.
- Graduation potential given a student has been "rolled-back".
- Profile of a successful student based on service record data.
- Recommendations for future study.

It should be noted that this paper is only an initial look at the cost associated with the BUD/S attrition problem. Certain conclusions derived from the database are based on a relatively small sample that may have been affected by other factors not reflected in the database. Caution should exercised when using the models based on small sample size.

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EXECUTIVE SUMMARY

The end of the cold war has equated to a reduction in the size of the military. This reduction can be directly seen in the reduced operating budgets of most commands. The Naval Special Warfare Center is no exception. This study examines the Basic Underwater Demolition / SEAL Training course in detail to provide insight into courses of action that will optimize the cost associated with training. This paper clearly shows inefficiencies in the current training procedures. The five steps that should be implemented immediately to reduce cost are:

- Implement the logit forecast model developed in this paper using data in student records in conjunction with a psychological profile test that is specifically developed for the BUD/S program to eliminate a minimum of ten percent of high risk applicants prior to issuing orders.
- Implement a maximum lead time prior to commencement of training for all students of approximately 77 days. Ensure that NMPC does not order students into BUD/S more than four weeks prior to a class convening date and ensure that the students understand that they are on a time line for graduation.
- Implement a process that updates NMPC at least weekly on student attrites in order to improve non-productive time after dis-enrollment.
- If students are unable to continue with training prior to "HELLWEEK," they should be dis-enrolled unless there are extenuating circumstances. If rolled-back prior to "HELLWEEK" they are allowed that one opportunity to graduate prior to being dis-enrolled.
- Modify PCS orders to BUD/S so that they are unaccompanied for the duration of the training.

From the data used in the study, it is clear there is a significant savings on all five steps listed above although no specific cost avoidance or savings could be determined for the last two. Initiating the first three steps should result in saving more than 37,000 man-days of labor each year, or approximately $1.3 million dollars in non-productive salaries. This does not account for the hours of instructor time wasted on trainees that fail nor the cost avoidance of PCS funds that are not spent if students can be screened from the program prior to issuing orders.

Also brought to light in the study are several areas in which a more in-depth study should be conducted. These are:

- Modifying the curriculum in an attempt to remove the majority of the attrites prior to conducting PCS orders. For example, it may be cost effective to conduct up to and including "HELLWEEK" at a east and west coast location. Once an individual has successfully completed "HELLWEEK" he would be transferred PCS to Coronado to complete the course.
- Conduct an analysis of graduates that were rolled-back during pool competency compared to students who were dis-enrolled after being set back during pool competency. Determine if individuals should automatically be rolled-back or dis-enrolled after failing this portion of training.
- The medical rehabilitation program should be closely examined to determine if students that have not successfully completed "HELLWEEK" should be retained if unable to continue with their assigned class.

This study examined the Basic Underwater Demolition / SEAL training course. The procedure used in this study should be conducted on any course in any service that has a historically high attrition rate or cost associated with its training in order to optimize the funds available.

I. INTRODUCTION

A. BACKGROUND

1. General

Sea Air and Land (SEAL) Teams have been one of this country's premiere Special Operation forces since their inception in the early 1960's. All SEAL basic training and most of the advanced Naval Special Warfare (NSW) courses are currently conducted under one command, the Naval Special Warfare Center (NSWC) located at the Naval Amphibious Base (NAB) in Coronado, California. The initial SEAL training course is known as Basic Underwater Demolition/SEAL (BUD/S) training. Currently, the course is twenty-five weeks long and there are five classes trained each year. Each training class is assigned a sequential number, and most references to that class are by its designated number.

There are many synonymous references to various portions of the training, and this paper will attempt to reduce any ambiguity by limiting these references where possible, or by explaining in detail what is being referred to specifically. First, clarification is required to ensure proper understanding of terminology in this study.

Students are not "in training" the entire time they are attached to NSWC. Upon arrival, students are placed in a holding status until there is a class convening date and they are deemed physically able to become part of a training class. Also, students who are

injured or are below certain performance standards during a particular phase of training may be placed in a "rolled-back" status rather than being dis-enrolled. The time spent in these states is not considered part of the course of instruction. A class convening date is the official first day of training for that class. The actual course of instruction is divided into three phases as shown in Figure 1.

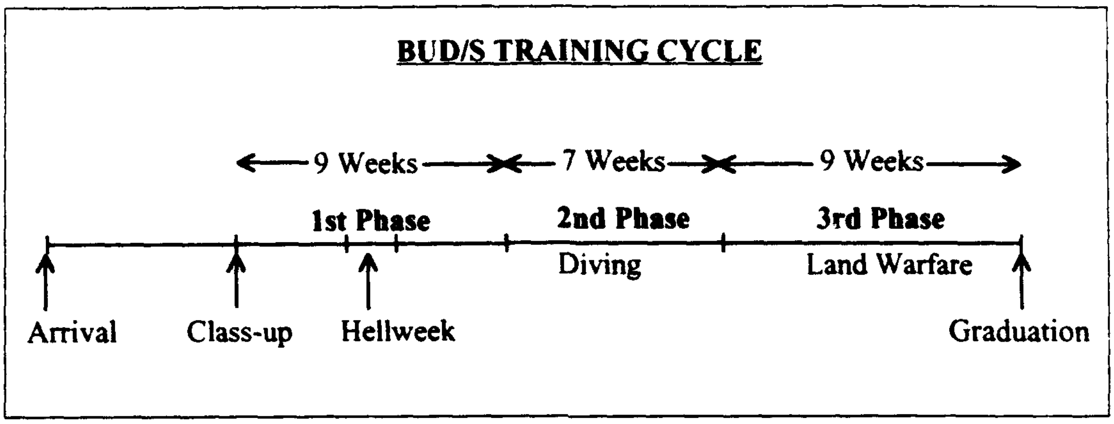


Figure 1. Phase Diagram.

First Phase is nine weeks long with the sixth week being called "HELLWEEK." The five weeks leading up to "HELLWEEK" are basic conditioning that emphasizes team work along with some basic skills that include swimming and small rubber boat handling. "HELLWEEK" has been thought of as the make or break point of most student's psychological ability. Beginning Sunday night and continuing until Friday afternoon the trainees are kept cold, wet, tired and hungry through a wide variety of exercises and competitions. This week is where the greatest rate (and often number) of voluntary drops occur.

After the ordeal of "HELLWEEK" students are given a recovery week. During this week training still begins at 0500 with physical training, but much of the rest of the day is classroom time devoted to learning different methods of hydrographic reconnaissance. The final two weeks of this phase are dedicated to practical applications of hydrographic reconnaissance. Most references to First Phase are typically subdivided into two parts:

- prior to and including "HELLWEEK," referred to as pre-"HELLWEEK."
- after "HELLWEEK," referred to as post-"HELLWEEK" or hydrographic reconnaissance.

The final two phases of BUD/S training; diving and land warfare, have exchanged location several times in the syllabus over the history of the course. There have been various arguments for each change. This paper will not investigate the various arguments. For portions of this study that might be affected by the exchange of phases, only recent data that has been obtained since the last change will be used. That was November 1990. Other portions of this study will use data obtained since 1986.

Currently, the second phase of BUD/S training is an introduction to diving. During this seven week phase, students are taught the basic skills of combat diving. These skills begin with open circuit diving (basic scuba), quickly move into closed-circuit diving (pure oxygen diving apparatus with no off gassing) and basic combat swimmer skills. This phase historically has the highest performance drop rate, which may be attributed to the students' inability to perform a variety of tasks in an aquatic environment.

Finally, the third phase is basic land warfare and demolition training. Lasting nine weeks, this phase gives trainees the foundation on how to conduct special operations. Again, this phase is often subdivided into two parts:

- Basic patrolling conducted in the vicinity of San Diego lasting approximately three and a half weeks.
- Weapons, demolition training conducted at San Clemente Island (SCI) lasting approximately four and a half weeks that culminates with several final training exercises (FTX) or full mission profiles (FMP).

The training received in this phase is the final step in the basic course. Students Who successfully complete this will go on to a future assignment in a SEAL or Swimmer Delivery Vehicle (SDV) Team. Once there, the basic foundation of land warfare and demolition training will be expanded. Obviously, the training cycle and length will vary depending on the occurrence of holidays.

2. Data

The data used in this thesis was obtained from the NSWC's Student Control. Student Control has a record of all known trainees starting with the first training classes during World War II. These records are kept in paper form in one of two alphabetical files, those prior to 1986 and 1986 to present. In November 1990 a computerized database was established to assist in tracking of student status. Some effort was made to copy old records from the card file to the electronic medium, but most of this information is not complete and therefore was not used in this study.

Currently, the database in use is Clipper5, a DBaseIII PLUS compatible format. Two major files in the database contain the majority of the information required for this

study. These files contain the training records of 3013 students. As could be expected, early entries in the database have a greater tendency to be incomplete or inaccurate due to the evolving procedure for entry of the data.

Several other studies have been conducted concerning the attrition rate of the BUD/S course. Of these studies, the one that may have some impact on reducing the training cost was researched and written by Laura Arroyo titled "Basic Underwater Demolition/SEAL Training Sports Psychology Intervention Program."

Miss Arroyo's study began in 1985 and continued through 1990 and is based on her personal observations, tests she administered and interviews she conducted. Although not directly relating to the reduction of cost, her study focused on psychological profiles of both graduates and dis-enrollments. Some of the results of this study will be brought forth in Chapter IV, the discussion portion of this study.

B. OBJECTIVE

The primary objective of this study is to reduce the cost associated with the basic training at NSWC. This is achieved through three events. First, a detailed analysis of the current system and costs associated with the basic training. Second, development of a logit regression model to provide a forecast of student graduation probabilities. Finally, a discussion of potential modifications to the current system that will reduce cost and/or increase productivity in man-hours of labor. Based on this information an optimal policy

can be provided as a potential guide for increasing the efficiency of the BUD/S training course. Specific details that are analyzed include:

- Determination of attrition rates for each type of dis-enrollment.
- Correlation of attrition rates and time on board the command.
- Correlation of attrition rates and class convening dates.
- Potential for graduating given a student is rolled-back.
- Student forecast model based on service record information.
- Examination of time to transfer after dis-enrollment.

This study will not cover all possible topics that may relate to student attrition, but it will recommend any topics that may impact on both cost and quality of future SEAL training. These recommendations will be based on facts and suppositions uncovered during the analysis of the data that either do not directly affect the objective of this stuc are too broad to be covered by this thesis, or have come into focus to far along to be included in this study.

II. METHOD

A. DATA TREATMENT

The Clipper5 database contains information on all personnel who have attended BUD/S training since 1990. In Clipper5 there are two DBaseIII files that contained relevant information. These are:

- BUDS.dbf -- contains student report dates and personal/background data as well as limited school-specific data, such as: class up date, class number, final event (disposition of the individual) and other relevant information.
- STU_HIST.dbf -- contains a diary-like record of significant events and dates for most of the students who did not finish training with their original class for whatever reason.

These two files contain the entire history of each student, tracing their steps from their previous command through their transfer to their following command. Other data contained in the files include Armed Services Vocational Aptitude Battery (ASVAB) scores, marital status, ethnic background, etc. There are a total of 59 fields of information in the two files of interest.

For all aspects of this study, only U.S. Navy students who, prior to 24 April 1993, had the opportunity to graduate (GRD) or be dropped from training for one of the four categories: administrative (DRA), medical (DRM), performance (DRP) or voluntary (DRV) were used. This database with other constraints placed on it, provided the main information for this study.

With over three thousand trainees and all their associated field information listed in the files the data was thinned to make it more readily usable on a personal computer. The process taken to thin this data is as follows:

- DBF files were retrieved into a spreadsheet program.
- All non-pertinent information was deleted from the files.
- All non-U.S. Navy personnel were deleted from the database.
- The BUDS.dbf and STU_HIST.dbf were cross referenced with each other, via a relational database. This produced a list of students who appeared in both files and had a final event entry.
- All students who had not completed training or been dis-enrolled prior to 24 April 1993 were deleted. This removed all students who were still at the command when the database was compiled.
- Once the data had been thinned, the file was saved in the spreadsheet format that was in use. This file is the basic file referred to throughout this study.

B. ANALYSIS

1. Attrition Rates

a. Overall Distribution

Without modification, the basic database was used to determine the proportion of students in each of the four possible dis-enrollment categories and an overall attrition rate. This was achieved by retrieving the basic file into a spreadsheet and sorting the data by final event code. The total number of students in each final event category divided by the total number of trainees in the database gives the proportion of personnel that are in each of the possible outcomes. This process includes students who do not "class-up" for what ever reason. This may be of some importance when discussing the

failure rate since students who are in a holding status when dis-enrolled are not technically in one of the phases.

b. Distribution Given a Student Began Training

The next step in modeling the attrition rates used the four standard dis-enrollment categories and a cumulative dis-enrollment category to create models depicting student attrition. For this portion of the study, a student who is dis-enrolled while in a roll-back status is counted as an attrite from the phase of training he was rolled-back from, and his drop date is the day he was rolled-back from that phase. This gives a more useful view of what points in training students are attriting.

The basic data file was modified. All students who arrived prior to 18 September 1990 were deleted. Since all students arriving after this date were trained under the current curriculum, this deletion removes any of the effects that the change in training cycle described in Chapter I may have had. The proportion of dis-enrollments of the modified basic file was calculated and compared to the overall rates to determine if there was an effect from this reduction.

Next, all graduates and all students who never classed up were deleted from the modified basic file. Students remaining in the basic file were sorted into two categories, those that were never rolled-back and those that were. This reduced the complexity of the calculations required to analyze this portion of the study. Students who were never rolled-back were a simple subtraction operation, while those that were

rolled-back required cross checking of their individual records to determine at what point their dis-enrollment occurred.

Two time periods were calculated for each of the students remaining in the basic file:

- The number of days from his class convening date to his final event, with the removal of time spent in a roll-back status (number of days in training).
- The number of days from his reporting date to his final event (number of days at the command).

These two calculations were sorted via spread sheet to identify any obvious erroneous data. Any data that was obviously entered incorrectly was corrected. All the usable records were divided into two groups. The separation was accomplished by sorting the students by Social Security Number (SSN). Even numbers were used for the model and odd numbers were used for cross-checking purposes.

From these files, histogram plots were created. These histograms were used to give an initial impression if any obvious underlying distribution existed. An attempt was then made to fit the data to known distributions in each of the following five categories:

- Overall attrites.
- Administrative attrites.
- Medical attrites.
- Performance attrites.
- Voluntary attrites.

Descriptive models of these five categories were developed using the students with even SSNs. The models created were verified using the cross-check data on both the Chi-squared goodness of fit and the non-parametric K-S tests.

2. Attrition Rate Versus Time On Board The Command

This aspect of the analysis is an attempt to model the arrival time prior to the first day of training that would maximize a student's chances of graduation. The intent is to project the amount of time trainees require to adjust to the San Diego climate, while not exceeding a point where their motivation declines from being placed in a holding status.

This model uses a modified version of the basic file. As described in the "Attrition Rates" above, all students who had not arrived at NSWC prior to 18 September 1990 were deleted. The number of days a student arrived prior to training was then calculated by subtracting his report date from his class convening date. This is the total time a student arrived early. The significant time for students who never began training is the total number of days spent at NSWC prior to dis-enrolling. This was calculated from the students dis-enrollment date less his arrival date.

The data was sorted by the number of days at the command for those that never began training. The amount of time for individuals in each of these two categories was then examined to determine any glaring errors in the data. Any individuals who showed an exorbitant time on board prior to their first day of training or dis-enrollment were closely scrutinized. If an obvious mistake of entering the data was present the data was corrected.

Based on the range of student arrival days prior to the commencement of training, the most logical bin size for the data analysis was seven day increments. Records

in each increment were binomial, either a student succeeded at an event or he did not (i.e. he graduated or he did not, he classed-up or he did not).

The first model in this section examines the time required for students to begin training once they have reported to NSWC. This model attempts to bound the maximum time students should be permitted to remain at NSWC without commencing training. Let L be the total time prior to either classing up or dis-enrollment without classing up; let CLU be 1 if the individual begins training, 0 if not. The probability that the time required to begin training given that the student would eventually class-up is given by:

$$P\{L \leq l \mid CLU = 1\} = \frac{\sum_{i=14}^{l} t_i}{T}$$

where t_i is the number of students on board i days prior to commencement of training, l is the lead time of interest, T is the total number of students who eventually would class-up given unlimited time in preparation. Thus

$$T = \sum_{i=14}^{427} t_i$$

Next, the proportion of graduates was determined for each bin. Each weekly increment was examined to determine any significant changes or obvious trends in graduation rates. Let Y be 1 if the individual graduates, 0 if not. The weekly graduation rate for students who begin training is:

$$P\{Y = 1 \mid L = l\} = \frac{g_l}{t_l}$$

where g_i is the number of graduates that were on board i days prior to their class convening date and t_i is the number of students who were on board i days prior to commencement of training.

The cumulative proportion of graduates to students who actually began training (both as a function of time prior to commencement of training) shows the optimal lead time to attain the highest graduation rate. This is calculated from the following:

$$P\{Y = 1 \mid L \leq l, CLU = 1\} = \Sigma_{i=14}^{l} \frac{g_i}{t_i}$$

where $P\{Y = 1 \mid L \leq l, CLU = 1\}$ is the probability a student graduates given his lead time is less than l and he began training and g_i, t_i and i are as described above.

Finally, a cumulative proportion of graduates to students who either classed-up or were dis-enrolled while in a holding status (also as a function of time on board the command) was examined to determine an optimal lead time including those students who never enter a class. The formula for this is:

$$P\{Y = 1 \mid L \leq l\} = \Sigma_{i=14}^{l} \frac{g_i}{p_i}$$

where g_i is as above and p_i is the number of potential trainees who either class-up or dis-enroll within i days of reporting to the command.

3. Attrition Rate Versus Class Convening Date

This portion of the analysis attempts to correlate time of year to attrition rate. Although San Diego is known for its moderate seasonal changes, the actual water temperature varies from a low of approximately fifty in Feruary/March to a high of the mid seventies in August/September. Since much of the training time students are either in the ocean or bay, it is reasonable to create a model based on the seasonal change. Obviously, the course is six months long and most students who graduate will be effected by the seasonal change, therefore a common event was required for the model. Since, during

"HELLWEEK," students remain cold and wet for the entire week and it is consider the psychological make or break point, this week was selected as the common occurrence.

The only data of interest were students who had actually classed-up. The basic file was modified, deleting students who were dis-enrolled prior to a class convening date. Note, for this section all students in the basic database that had classed-up were used since the common focal point of the model was prior to second phase, and therefore unaffected by the reshuffling of phases.

The proportion of graduates in each of the 25 classes contained in the database was calculated. This data was plotted with the month of each class' "HELLWEEK" being the x-axis and the proportion of graduates being the y-axis. The overall graduation rate was plotted on the same chart.

4. Graduation Potential Given Student Is "Rolled-back"

This section of the study investigates graduation potential given a student is rolled-back in a pre-"HELLWEEK" status or in a post-"HELLWEEK" status. For this portion of the study, only the first "roll-back" date is used if a student has been rolled-back more than once.

All students in the basic file that had not begun training or had not been rolled-back were deleted. Next, the dates that the students were rolled-back were examined to determine if their set back was pre- or post-"HELLWEEK."

The total number of graduates in category one divided by the total number of personnel in category one is the proportion that graduate given they are "rolled-back"

pre-"HELLWEEK." This same method was applied to those in category two, the post-"HELLWEEK" roll-backs. The pre- and post-"HELLWEEK" proportions were then compared with each other and the historical data to determine if there was a significant difference in the graduation rates. This process was expanded upon, and for each of the four drop categories a graduation proportion was determined both pre- and post-"HELLWEEK."

5. Forecast Of Successful Students

In this section, two multiple regression models are developed to created a profile of a student based on information available in his service record. One model is for officers and the other is for enlisted personnel. The distinction is due to several of the independent variables not being present in officer records. These profiles could be used in conjunction with other psychological and physical test and interviews to screen out potential high risk (low graduation potential) students in the future.

The basic file was modified deleting all fields not explicitly required for the regression. Next, the file was separated into two files, one consisting of officers only and the other of enlisted personnel. These were saved as text files to allow them to be manipulated using Statistical Analysis Software (SAS) for Elementary Statistical Analysis.

The models used are logit regression models with one dependent variable. The officer version contains five explanatory variables and the enlisted version eleven. The variables are based on the information provided in the BUDS.dbf file that were clear and

accurate. The following is the dependent variable definition, a forecast of student performance:

F_i = 0, if student i is forecast to fail.
1, if student i is forecast to graduated.

Of the fields in the database, five were common to both officer and enlisted models. Independent variables with an binomial response were transformed into dichotomous independent variables, others numeric variables were used as found in the individual records as follows:

- **Paygrade => x_1** -- E-1 through E-6 were assigned values of 1 through 6 and O-1 through O-3 were assigned values of 1 through 3.
- **Birthdate => x_2** -- Transformed into age. This is based on the individual's age when he arrives at NSWC.
- **Marital Status => x_3** -- Married = 0, Single = 1.
- **Reserve Status => x_4** -- Reserve = 0, Regular = 1.
- **Bodyfat percentage => x_5** -- Based on the bodyfat percentage shown on officer fitness reports and enlisted evaluations.

The remaining six explanatory variables pertain strictly to the enlisted community. The variables are:

- **Divefare Program => x_6** -- Did not enlist under the Divefare Program = 0, did enlist under the program = 1. This program guarantees recruits a billet to attend BUD/S training after they successfully complete their basic training.
- **EAOS => x_7** -- The number of years remaining on the enlistment contract based on the students arrival date.
- **ASVAB.VE => x_8** -- Verbal portion of the ASVAB.
- **ASVAB.AR => x_9** -- Arithmetic portion of the ASVAB.
- **ASVAB.WK => x_{10}** -- Working Knowledge portion of the ASVAB
- **ASVAB.MC => x_{11}** -- Mechanical portion of the ASVAB.

The hypothesized logistic regression models to be used have the following form:

$$P(F_i = 1) = 1/(1 + EXP[-(\alpha + \Sigma \beta_i x_i)])$$

$P(F_i = 1)$ is the forecast probability that a student graduates, as a function of the predictor variables x_1 - x_5 for the officer model, and predictor variables x_1 - x_{11} for the enlisted

model. The parameters α and β_j are similar to the constant and slope parameters found in ordinary simple regression.

6. Transfer Date After Dis-enrollment

While working with the data, it was noted that some of the transfer dates after an individual is dis-enrolled from training were exceedingly long. The basic file was examined and all records reflecting both dis-enrollment date and transfer date were selected. Following the same procedure described in "Attrition Rates" above, a model was created to depict the time spent at NSWC after dis-enrollment.

7. Estimated Potential Savings

Based on salaries of the students at the command, the average cost and the marginal cost per graduate were calculated and graphed based on the lead time. Average cost per graduate is determined by summing the daily base pay for each trainee multiplied by the number of days prior to that individual's class convening date divided by the number of graduates. This is done for each time period and is shown by the following equation:

$$AC(l) = \Sigma_{i=14}^{l} \frac{c_i}{g_i}$$

where $AC(l)$ is the average cost as a function of lead time, g_i is the number of graduates with lead time i, and c_i is the sum of the individual salaries paid to trainees for time on board the command prior to commencement of training or dis-enrollment with lead time i. The sum of all salaries prior to and including day l, divided by the number of graduates that began training by day l is the average cost per graduate.

Base pay was determined from the Navy's monthly pay chart with the number of years of service being estimated from an average of the individual ages in each paygrade. The monthly pay multiplied by 0.032877 is the daily salary for each individual in that paygrade.

The marginal cost was based on the difference between the cost of two consecutive time periods divided by the number of graduates between those same time periods. The formula for marginal cost is:

$$MC(l) = \frac{c_l}{g_l}$$

where $MC(l)$ is the marginal cost as a function of lead time, g_l is the number of graduates that had $l-7$ to l days on board the command prior to starting training and c_l is sum of the individual salaries paid from $l-7$ to l days.

Next, a model was built to reflect the potential proportion of savings in salaries versus the proportion of graduates, both based on lead time prior to starting training. This model gives a view of the trade-off between savings in salaries and the proportion of graduates based on lead time. The equation used to determine proportion of graduates is:

$$P\{L \leq l \mid Y = 1\} = \frac{\sum_{i=14}^{l} g_i}{\sum_{i=14}^{427} g_i} = \frac{\sum_{i=14}^{l} g_i}{G_{Total}}$$

where $P\{L \leq l \mid Y = 1\}$ is the probability that the lead time is less than or equal to l given the individual graduates, g_i is as before and G_{Total} is the total number of graduates. The equation used to determine the proportion of savings in salaries is:

$$PS(l) = \frac{\sum_{i=l+7}^{427} c_i}{\sum_{i=14}^{427} c_i} = \frac{\sum_{i=l+7}^{427} c_i}{C_{Total}}$$

where $PS(l)$ is the proportional savings in salaries, c_i is as stated above and C_{Total} is the total salaries paid to trainees prior to commencement of training or dis-enrollment. Note that 427 days is the maximum lead time for any student in the database.

Along the same theme, a model was created to examine the actual number of days an individual required to graduate once training began. The course is a minimum of 170 days in length. If an individual is in a training class during the Christmas break a minimum of 14 days is added to the course. If an individual is rolled-back, he must wait until the next class is at the beginning of the phase or portion of the phase from which he was rolled-back. Currently, there is a fifty six day separation between classes, so an individual held back will most likely be on board a minimum of 236 days. If his time includes a Christmas break this number increases to approximately 250 days. This model gives the decision maker a view of the trade-off between savings in salaries and the proportion of graduates based on time since classing up. The equation used is:

$$P\{L_T \leq l_T \mid Y = 1\} = \frac{\sum_{i=150}^{l_T} g_i}{\sum_{i=150}^{590} g_i} = \frac{\sum_{i=150}^{l_T} g_i}{G_{Total}}$$

where $P\{L_T \leq l_T \mid Y = 1\}$ is the probability that the time required to graduate once training has begun is less than l_T given the individual graduates, g_i is the number of graduates that required l_T-19 to l_T days after class up to graduate and G_{Total} is the total number of graduates. The equation used to determine this proportion of savings is:

$$PS(l_T) = \frac{\sum_{i=l_T}^{590} c_i}{\sum_{i=150}^{590} c_i} = \frac{\sum_{i=l_T+20}^{590} c_i}{C_{total}}$$

where $PS(l_T)$ is the proportional savings in salaries as a function of time after students begin training (l_T), c_i is the sum of the individual salaries paid to trainees from the

beginning of training to day i and C_{Total} is the total salaries paid to trainees from their class up date. Note that 590 days is the maximum time required after commencement of training for any student to reach a final event.

Finally, the cost estimate associated with the time that students spend at NSWC after having been dis-enrolled is simply the average salary of a student multiplied by the average number of days spent at the command once dis-enrolled.

III. RESULTS

A. GENERAL

Using the methods described in Chapter II, the database was thinned and all complete student records containing the required fields were retained in one spreadsheet based file. Table 1 displays the results of the thinning process. The basic file contains 2,445 complete

TABLE 1. THINNING OF DATABASE.

Total students listed in BUDS.dbf	3,013
Total U.S. students	2,933
Total students with final events	2,445
Total students after 18 Sept. 1990	1,455

records. During various portions of the study only complete student records after the change in curriculum were used, this further thinned the database as shown.

B. ANALYSIS

1. Attrition Rate Models

a. Overall Distributions

A comparison of proportions of trainees in each final event category in the last two steps of the thinning process is shown in Table 2. This comparison was conducted in an attempt to determine if the thinning process effected the overall distribution of the population. Although there appears to be a distinct variation in the

percent of graduates and voluntary dis-enrollments between the final two categories in the thinning process, the percentage change proves not to be significant.

Additionally, this variation may also be explained with a closer examination of the history of the data itself. As mentioned in Chapter I, the computerized database was not implemented until November of 1990. All records prior to this that are included

TABLE 2. COMPARISON OF FINAL EVENTS PROPORTIONS.

Event	students with final events	% of Total	Arrival after 9/18/90	% of Total
Graduates	837	34.23	421	28.93
Dis-enrolled for Administrative Reasons	93	3.8	67	4.6
Dis-enrolled for Medical Reasons	419	17.14	232	15.95
Dis-enrolled for Performance Reasons	191	7.81	125	8.59
Dis-enrolled for Voluntary Reason	905	37.01	610	41.92
Total	2,445	100	1,455	100

in the computerized database are records that have been entered "after the fact." A display of the results of an examination of student records from 1986 through 1990 not already included in the computerized database is shown in Table 3.

TABLE 3. STUDENT ATTRITION 1986-1990.

Event	Number	Percent
Graduates	595	32.23
Dis-enrolled for Administrative Reasons	55	2.98
Dis-enrolled for Medical Reasons	257	13.92
Dis-enrolled for Performance Reasons	167	9.05
Dis-enrolled for Voluntary Reasons	772	41.82
Total	1,846	100

The proportion of students in each of the dis-enrollment categories closely subscribes to the statistics excluding personnel prior to September 1990 shown in Table 2. The fact that the basic file's composition deviates from these two files is most likely attributed to slight differences in external variables and the process of entering back dated

information. The first back dated names entered into the database were from lists of graduates, additional records were entered as time permitted.

The modified basic file of 1,455 complete student records was divided into two files by SSN. A comparison of the distributions of the two sets was conducted over the four dis-enrollment categories and a total dis-enrollment category using the Chi-square goodness of fit and the K-S test to determine if the population is consistent. Results of the goodness of fit test are displayed in Table 4. Each category for both tests indicate there is no reason to reject the null hypothesis of there being a difference in the composition of the two samples.

TABLE 4. CHI-SQUARE AND K-S TEST RESULTS.

Final Event	# Even SSN	# Odd SSN	Chi-square test stat	Chi-square 0.950	K-S test stat	K-S 0.950
DRA	12	20	3.25	7.82	0.32	0.5
DRM	45	56	5.1	9.49	0.12	0.27
DRP	49	53	1.09	9.49	0.12	0.27
DRV	178	181	6.67	11.07	0.07	0.14
Total	284	310	12.08	12.59	0.05	0.11

b. Distributions Given a Student Began Training

The occurrence of student attrites in each of the four distinct categories and the total dis-enrollment category was modeled on A Graphical Statistical System (AGSS). A summary of all significant findings is displayed in Table 5 with histograms of their distributions and the complete output from AGSS available in Appendix A. Only dis-enrollments for administrative (DRA) reasons could be modeled from a known distribution. The DRA category fit the exponential distribution and was verified by the

Chi-square goodness of fit and the K-S tests. All other models are displayed as empirical distributions.

TABLE 5. SIGNIFICANT RESULTS OF DIS-ENROLLMENTS.

Category	Model	Median	Mean	Standard Deviation	Upper Quartile
DRA	Exponential	32	47.71	39.86	77
DRM	Empirical	21	28.23	27.53	32
DRP	Empirical	76	67.39	37.53	90
DRV	Empirical	35	29.23	17.58	36
TOTAL	Empirical	32	36.55	29.35	37

2. Attrition Rate Versus Time On-Board the Command

These models attempt to show the maximum time prior to the commencement of training that students should arrive. As stated in Chapter II, the basic file was used. Once the basic file had been modified and the number of days prior to commencement of training calculated, the data was analyzed. Figure 2 is a graph of the proportion of

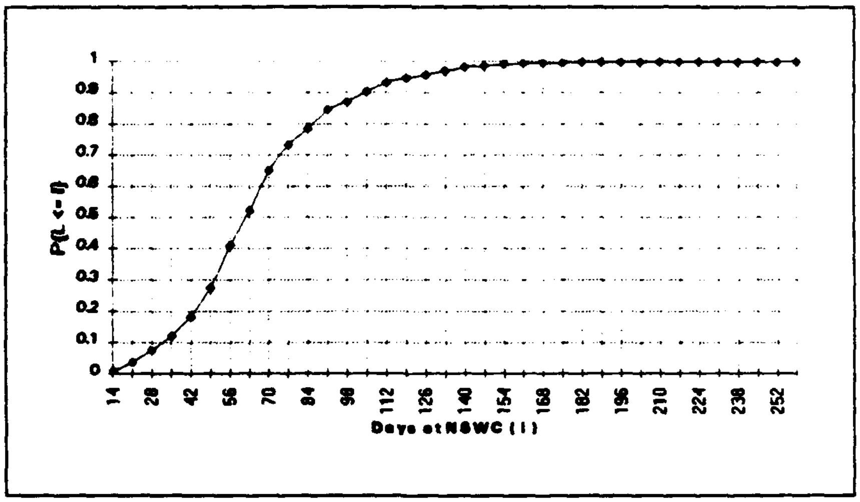


Figure 2. Days Required To Begin Training.

students who began training to the number of days on board the command. While modifying the basic file it was determined that 27 percent of the students never enter a

class. This fact was further investigated and it was determined over 99 percent of all trainees who will eventually enter a class will do so within 154 days of reporting. Selecting a lead time of 56 days as an example, this chart shows that 41 percent of all trainees who would begin training given an infinite lead time would have begun by day 56.

The next effort was to determine if there was a significant difference in graduation rates. A chart of the proportion of students who graduated and began training between *l-6* to *l* days after arriving at the command was created, Figure 3. A simple linear regression was run, and an R^2 of 0.513 was obtained for the following equation:

$$P\{Y = 1\} = \underset{(10.62)}{0.587} - \underset{(4.23)}{0.00272l}$$

where $P\{Y = 1\}$ is the probability of graduation given on board *l-6* to *l* days. The

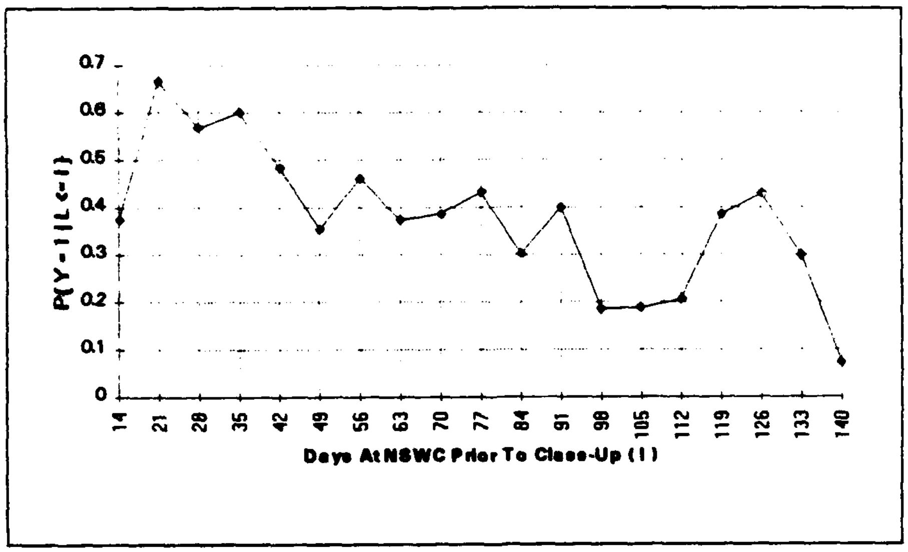


Figure 3. Weekly Graduation Rate For Students Who Begin Training.

Chi-square statistics are shown in parenthesis. Both intercept and slope are significant. If 42 days is the lead time of interest, 48 percent (32 graduates of 66 students) of those students who began training with a lead time of 36 to 42 days graduated.

Next, two charts were created that show the cumulative proportion that graduate given they were on board *l* days or less. The first chart, Figure 4, is the cumulative probability a student graduates given the student is on-board less than or equal to *l* days and he began training. This chart indicates a significantly higher maximum graduation rate for *l* between 21 and 42 days. The maximum value is approximately 60 percent before tapering down to just under 40 percent. This figure is cumulative as a

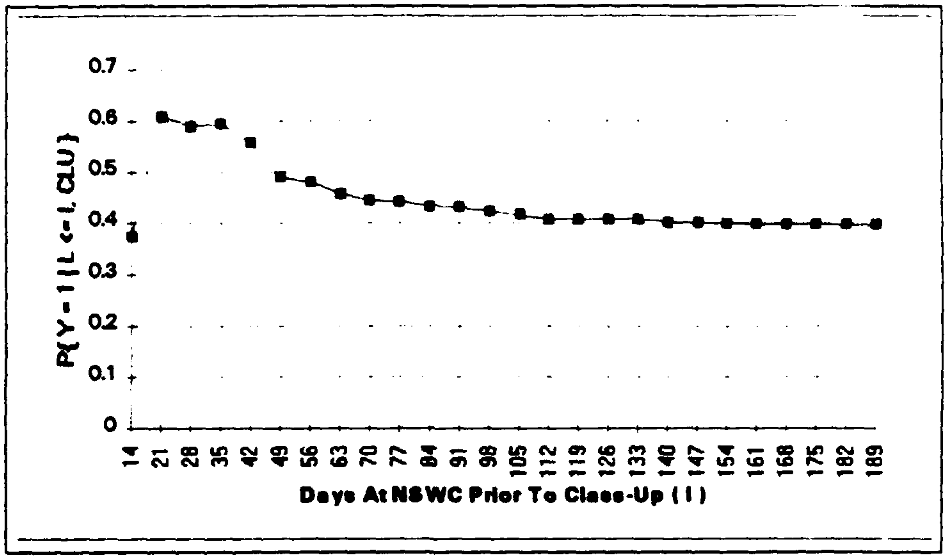


Figure 4. Probability Of Graduation Given On-Board Less Than *L* Days And Began Training.

function of lead time. Using 42 days as the lead time of interest shows 56 percent of all students who began training within 42 days of reporting to the command graduated. That is the sum of the graduates with a lead time of 14 through 42 days divided by the sum of the trainees who began training with a lead time of 14 through 42 days.

Figure 5, is very similar to Figure 4. The difference is that this chart incorporates all students at the command with a lead time *l* whether or not they began

training. This inclusion significantly reduces the graduation rate and severely dampens the magnitude of the maximum graduation rate. As shown, the highest cumulative graduation probability occurs on approximately day 77 at 32 percent and tapers off to a steady state average of just under 29 percent. Selecting a 35 day lead time indicates that 25 percent of

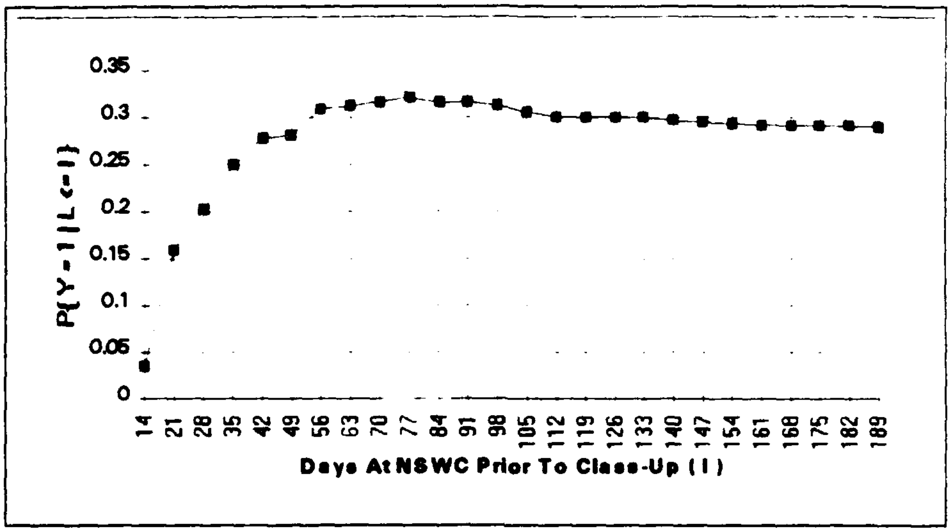


Figure 5. Probability Of Graduation Given On-Board Less Than *L* Days.

all students at the command that either began training or dis-enrolled within 35 days of reporting actually will graduate. All data used to create these figures can be seen in Appendix B.

3. Attrition Rate Versus Class Convening Date

An attempt was made to create a model linking class convening date with graduation. The database only contained 25 classes of graduates. For the reasons described in Chapter II, "HELLWEEK" was selected as the point of interest and a plot (Figure 6) of the graduates was created. The plot reveals little information other than the majority of "HELLWEEKs" in the database occurred in the last half of a year. The overall

average graduation proportion is 0.45. Averaging the graduation proportion by month, the greatest deviation from the norm (excluding March since it only contained one data point incorporating 24 students) is nine percent and this is derived from only three observations. From this there is no reason to reject the hypothesis that all observations

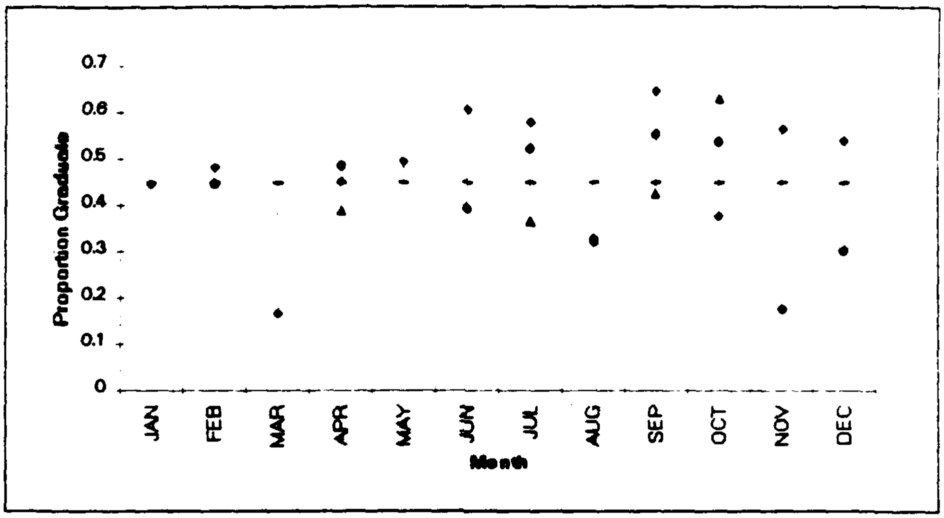


Figure 6. Proportion Graduate Verses "Hellweek" Month.

are from the same population. There does not seem to be a significant link between class convening date and attrition rate as was speculated earlier. All data used to create this figure can be seen in Appendix C.

4. Graduation Potential Given Student is "Rolled-Back"

This portion of the study examined the probability that a student would graduate given he was rolled-back during some portion of the training cycle. Once the basic file had been modified, there remained 1682 records in the database. Of this, 966 were of students who either graduated or dis-enrolled without being set back. The other 716 records were students who had been rolled-back at least once. Table 6 is a display of the

findings. The table clearly shows that there is no significant difference between students who are rolled-back and those that are not, unless the roll backs are subdivided into pre- and post-"HELLWEEK."

TABLE 6. GRADUATION PERCENT GIVEN ROLLED-BACK.

	Number of Students	Number of Graduates	Percent Graduate
Pre-"Hellweek" roll	407	98	24.08
Post-"Hellweek" roll	309	206	66.67
Total roll-back	716	304	42.46
Did NOT roll-back	966	417	43.17
Overall	1,682	721	42.87

Next the pre- and post-"HELLWEEK" dis-enrollments were examined to determine the type of dis-enrollments. Table 7 shows the official reasons individuals left training.

TABLE 7. DIS-ENROLLMENT PERCENT.

	Pre-"Hellweek"		Post-"Hellweek"	
	# Students	% of Total	# Students	% of Total
DRA	18	5.83	16	15.53
DRM	129	41.75	17	16.5
DRP	53	17.15	49	47.57
DRV	109	35.28	21	20.39
Total DR	309	100	103	100

5. Forecast of Successful Students

All models developed to profile students who are more likely to graduate were constructed using SAS. Three models were constructed for the officer file and the enlisted file. The models are:

- A full logit regression using all available explanatory variables.

- A stepwise logit regression with the critical P-value for entry of an explanatory variable being 0.05.
- A stepwise logit regression with the critical P-value for entry of an explanatory variable being 0.30.

Beneath each of the explanatory variables in the models displayed is the chi-square statistic for that variable. SAS also determines the Akaike Information Criterion (AIC) and the Schwartz Criterion (SC). These are two methods for comparing various models based on the same data. In both cases the lower the statistic the better the model.

Included in the SAS output is the proportion of students predicted to dis-enroll who actually graduate labeled False Positive (Type I Error) and the proportion of students predicted to graduate who actually dis-enroll labeled False Negative (Type II Error). A portion of the classification table for these models is displayed with each model. These tables depict the proportion of student the model correctly predicted using the criterion for decision of $P(F_i=1) > 0.5$. The full SAS output for each model can be examined in Appendix D.

a. *Officer Logit Model*

The officer models are not likely very robust. The number of students available to construct the models was limited to 95 individuals. A larger data set could be obtained if the restriction on allowing student records prior to 18 September 1990 were removed. This was rejected based on the change in curriculum as explained in Chapter I.

The first model containing all explanatory variables is:

$$(\alpha + \Sigma \beta_i x_i) = \underset{(7.262)}{-13.9721} - \underset{(2.229)}{0.8604X_1} + \underset{(6.984)}{0.5523X_2} - \underset{(0.032)}{0.1516X_3} + \underset{(0.115)}{0.2797X_4} + \underset{(1.459)}{0.0876X_5}$$

For reference, from Chapter II, the definition of these explanatory variables are displayed below:

- x_1 = **Paygrade**.
- x_2 = **Birthdate.**
- x_3 = **Marital Status**.
- x_4 = **Reserve Status**.
- x_5 = **Bodyfat percentage**.

This model had no criteria to reject any of the explanatory variables regardless of how insignificant the T-statistic appeared to be. The AIC for this model is 110.962 and the SC is 126.285. A partial classification table is shown in Table 8 where $P(F_i=1) > 0.5$. The proportion of the time this model is correct at this critical value is 72.6 percent, the Type I error is 45.5 percent and the Type II error is 25.0 percent.

TABLE 8. FULL OFFICER LOGIT MODEL.

	Observed		
	$P(F_i$=Grd$) > 0.5$	Graduate	Dis-enrollment
Predicted	Graduate	63	21
	Dis-enrollment	5	6

The second model, a stepwise logit regression with an entry level P-value of 0.05 is displayed below. Note, having failed to meet the criteria for being included in the model, X_1 (Age), X_3 (Married), X_4 (Reserve) and X_5 (Bodyfat) are excluded. The model is:

$$(\alpha + \Sigma\beta_i x_i) = \underset{(12.596)}{-8.5853} + \underset{(10.259)}{0.3143X_2}$$

The AIC for this model is 105.841 and the SC is 110.949. The partial classification table for this model where $P(F_i=1) > 0.5$ is the same as the full officer logit model at this same value. For other critical values, the predictions differ. Also, the construction of the final

officer model with an entry level P-value of 0.30 produced the same results as this stepwise logit model.

The stepwise officer logit model is the best fit based on the AIC and SC statistics. A plot of the stepwise model's percent correct, type I error and type II error for the varying critical probability values is shown in Figure 7. Clearly, the lack of smooth

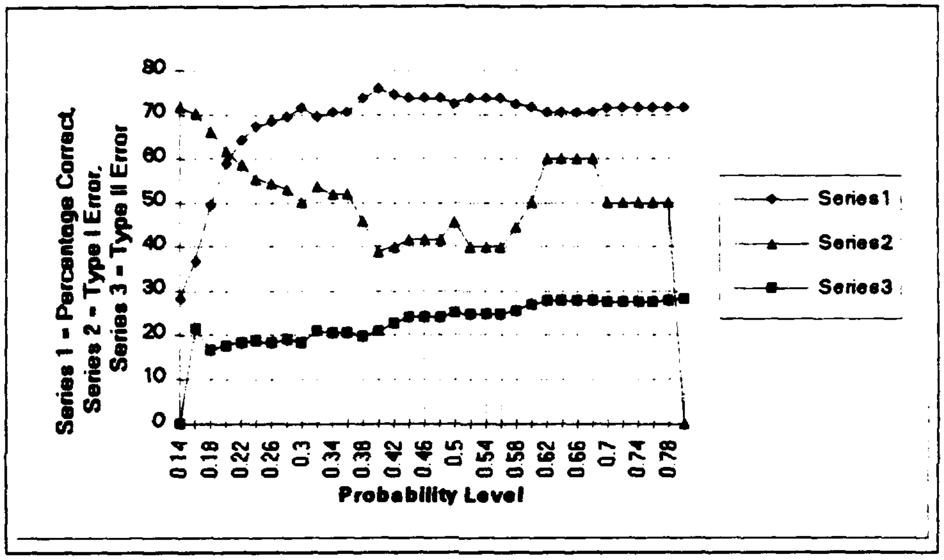


Figure 7. Officer Stepwise Logit Percentages.

curves for these three series indicates the model is not very robust, although some general trends can be made from the plot.

b. Enlisted Logit Model

The enlisted models are based on 1317 complete student records. An attempt was made to randomly divide the data set in two, holding the second set of data for cross check purposes. A comparison of the models developed with the entire data set and models developed with the reduced data set showed that the models had nearly the same predictive power when applied to the cross check data set. The models constructed

with the full data set had slightly more conservative results in every case. Therefore this study used the entire data set to build the models for the enlisted students.

The first model containing all explanatory variables is:

$$(a + \Sigma\beta_i x_i) = \underset{(2.407)}{2.1909} - \underset{(145.921)}{1.0834X_1} + \underset{(24.961)}{0.1695X_2} - \underset{(8.399)}{0.6130X_3} + \underset{(4.344)}{1.0256X_4} + \underset{(36.425)}{0.1231X_5}$$
$$+\underset{(5.355)}{0.3897X_6} - \underset{(36.276)}{0.4847X_7} - \underset{(0.813)}{0.0329X_8} + \underset{(0.011)}{0.0015X_9} + \underset{(1.950)}{0.0467X_{10}} - \underset{(11.848)}{0.0453X_{11}}$$

Again to clarify the explanatory variables, the definitions are displayed below:

- **x_1 = Paygrade**.
- **x_2 = Birthdate**.
- **x_3 = Marital Status**.
- **x_4 = Reserve Status**.
- **x_5 = Bodyfat percentage**.
- **x_6 = Divefare Program**.
- **x_7 = EAOS**.
- **x_8 = ASVAB.VE**.
- **x_9 = ASVAB.AR**.
- **x_{10} = ASVAB.WK**.
- **x_{11} = ASVAB.MC**.

The AIC for this model is 1273.773 and the SC is 1335.970. Again, with $P(F_i=1) = 0.5$, a partial classification table of the full enlisted logit regression model is shown in Table 9.

TABLE 9. FULL ENLISTED LOGIT MODEL.

	Observed		
	$P(F_i$=Grd) > 0.5	Graduate	Dis-enrollment
Predicted	Graduate	114	71
	Dis-enrollment	231	901

The overall proportion correct associated with this particular portion of the classification table is 77.1 percent, the Type I error is 20.4 percent and the Type II error is 38.4 percent.

With a P-value of 0.05 selected to determine if explanatory variables will be included in the model, the second enlisted model was constructed. In this stepwise model, SAS excluded the following explanatory variables, X_8 (ASVAB-VE), X_9

(ASVAB-AR) and X_{10} (ASVAB-WK) for failure to meet the required P-value. The model developed is shown below:

$$(\alpha + \Sigma \beta_i x_i) = \underset{(5.627)}{2.6360} - \underset{(148.124)}{1.0876X_1} + \underset{(28.008)}{0.1762X_2} - \underset{(8.035)}{0.5986X_3} + \underset{(4.320)}{1.0230X_4}$$

$$+\underset{(36.385)}{0.1219X_5} + \underset{(5.975)}{0.4076X_6} - \underset{(36.297)}{0.4814X_7} - \underset{(12.219)}{0.0410X_{11}}$$

The AIC for this model is 1270.061 and the SC is 1316.709. The classification table for this model is shown in Table 10. As with the officer model, the second stepwise regression with a criterion for the explanatory variables entering the model of 0.30, produced the same model as the first stepwise regression. The proportion correct for this

TABLE 10. STEPWISE ENLISTED LOGIT MODEL (P=0.05).

	Observed		
	$P(F_i$=Grd$) > 0.5$	Graduate	Dis-enrollment
Predicted	Graduate	115	66
	Dis-enrollment	230	906

model was 77.5 percent, the Type I error is 20.2 percent and the Type II error is 36.5 percent.

As with the officer logit model, the best fit based on the AIC and SC statistics for the enlisted logit regression is either of the stepwise models. Again, a plot of the stepwise model's percent correct, type I error and type II error for the varying critical probability values is shown in Figure 8. Unlike the officer plot, the plot of the percent correct and the type I error are relatively smooth curves. The plot of the type I error does lose some of its smoothness at the upper end of the critical probability level. These shifts of one or two percent do not appear to be significant when evaluating the model. The plot of type II error below a critical level of 0.56 is not smooth though it is generally well

behaved and above this value is smooth. This indicates that the model is fairly robust and can be a good basis for decisions.

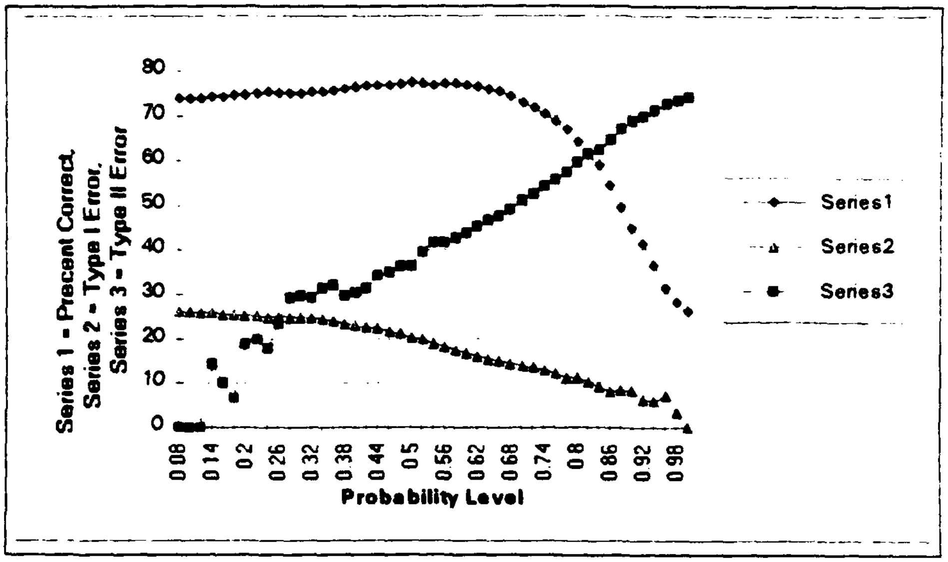


Figure 8. Enlisted Stepwise Logit Percentages.

6. Transfer Date After Dis-enrollment

Thinning the basic file left 363 records that contained both a dis-enrollment date and a transfer date. Details of the model developed in AGSS are shown in Table 11. A

TABLE 11. SIGNIFICANT FINDINGS OF TRANSFER DATA.

Model	Empirical
Mean	52.64
Standard Deviation	52.4
Median	36
Lower Quartile	25
Upper Quartile	56
Minimum Time	3
Maximum Time	514

histogram plot displaying the number of days an individual remained at NSWC after dis-enrollment and the entire AGSS output may be seen in Appendix E.

7. Estimated Potential Savings

All data required to create the figures in this section is located in Appendix F. From the equation in Chapter II, a chart of average cost per graduate as a function of lead time was created. Figure 9 is the chart. The range of the average cost is from a high of

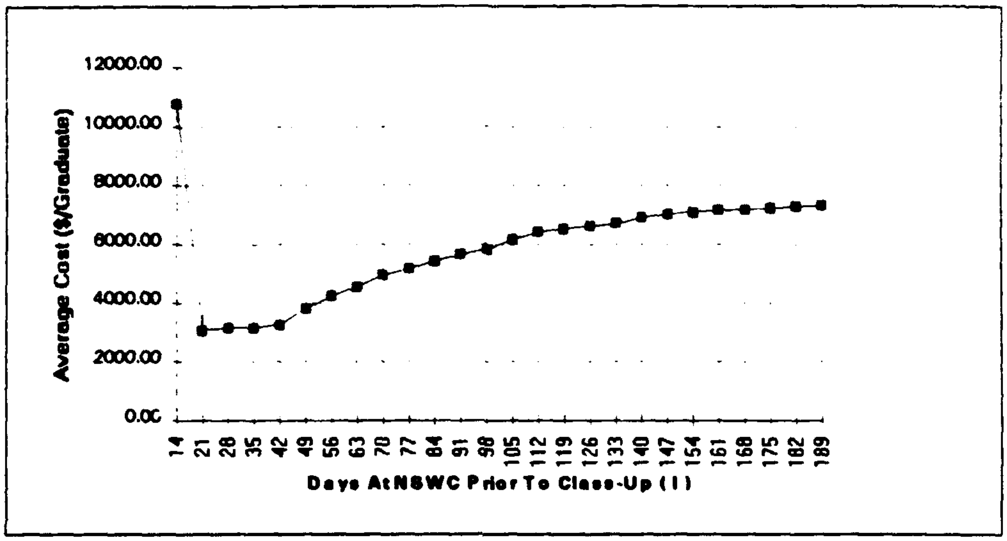


Figure 9. Average Cost Per Graduate.

$10,753.22 to a low of $3,062.81. The maximum occurs on day 14. The minimum occurs between 21 and 42 days. After day 42 there appears to be a increasing cost that achieves a steady state value of $7,500 per graduate.

Figure 10 is a plot of the marginal cost as a function of lead time. Note that the last four lead times in the series are not the standard bin size of seven days. This is due to only a single graduate in each of the last four lead times. The drastic decline in marginal cost after day 133 may be attributed to the single graduate for each of the last four lead times. The range in cost per graduate is from a low of $2,014.12 with a lead time of 14 days to a high of $95,411.79 with a lead time of 133 days. The minimum occurs with a

14 day lead and increases through a 77 day lead. The local maximum on day 98 can not be accounted for with the data available.

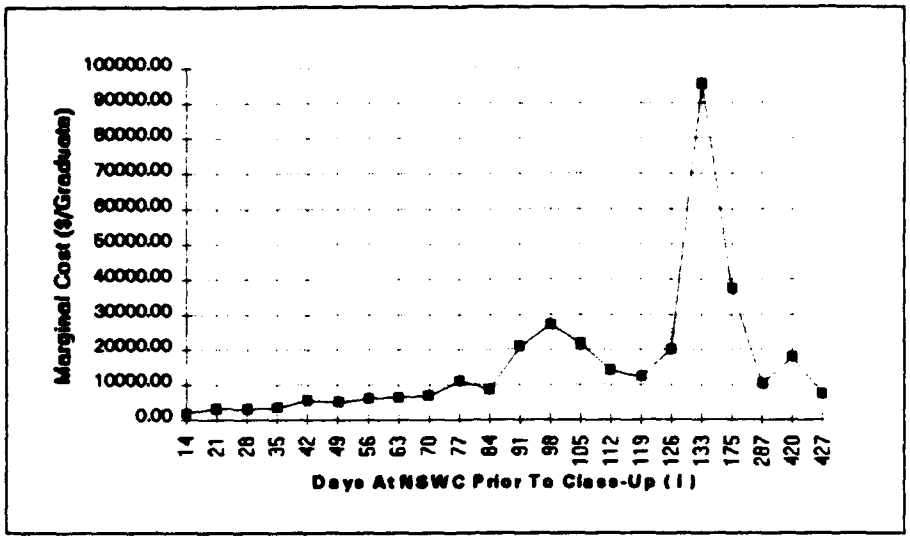


Figure 10. Marginal Cost Per Graduate.

The model that shows the proportion of graduates to the proportion of salaries saved is easiest to interpret through a chart which is shown in Figure 11. The first series

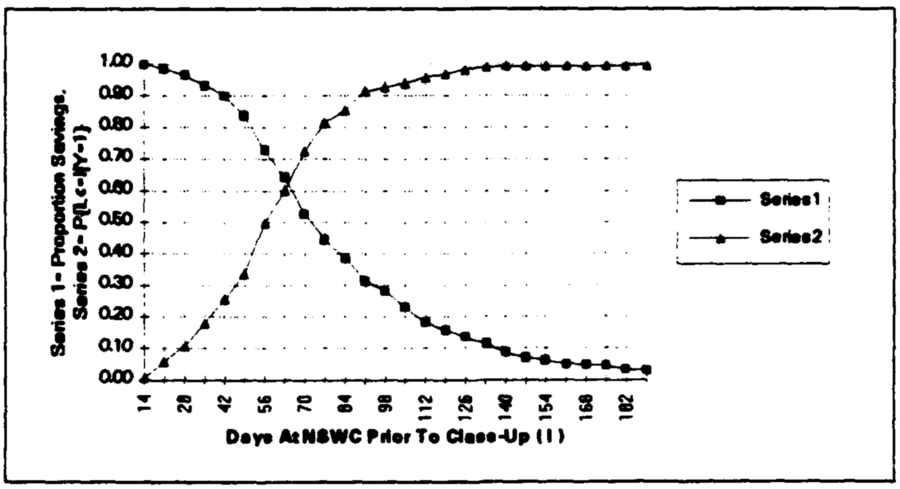


Figure 11. Probability Time Prior To Begin Is Less Than *L* Days Given The Individual Graduates Verse Proportion Of Salary Savings.

in this model shows the proportion of potential graduates that graduate with lead time less than or equal to *l* divided by the total number of graduates regardless of time prior to

classing-up. The second series on the graph indicates the potential proportional savings in trainee salaries when required to class-up by day *l*. For example, if trainees are required to begin training within 77 days of reporting to the command nearly 82 percent of all students who would graduate will have begun training. Also, the Navy would save approximately 44 percent in trainees salaries by requiring them to begin within 77 days. For the data used in this study, these charts show that at least 344 of the actual 422 aduates would have become SEALs while the Navy would have realized a savings of $1.39 million in non-productive salaries.

Examining the time required to complete training once the students have classed up is shown in a similar chart (Figure 12). Data used to create this figure is located in Appendix G. In this chart the maximum proportional savings in salaries is limited to less

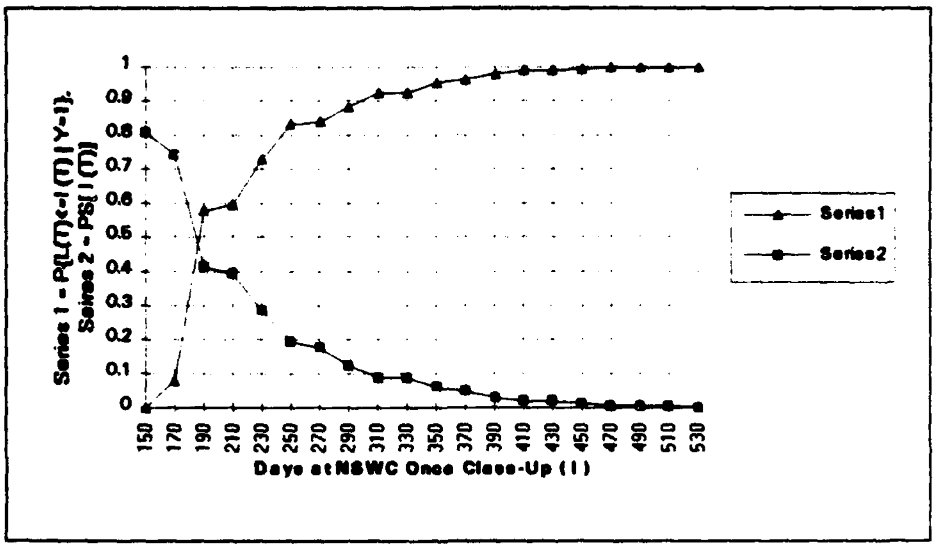


Figure 12. Days Required To Graduate.

than 80 percent. The reason for this is the salaries already paid to students who dis-enroll prior to being on board 170 days. The step in the chart at day 190 can be attributed to the

interval between classes for students who are rolled-back. This step can also be seen at days 250 and 310, although not as evident do to the clutter created by the various holidays and the decreasing slope of the series.

Finally, an estimate of salaries paid to students after they have dis-enrolled was calculated. The average daily student salary is $34.98. This multiplied by the mean number of days a student remained at the command after dis-enrollment (52.64 days) is $1,841.32 per student. These are non-productive salaries.

IV. DISCUSSION

A. GENERAL

The thinning process reduced the number of personnel records available for the study from over 3,000 to 1,455. These reductions were necessary. Rules governing foreign student enrollment are sometimes modified for political reasons. Of the 488 U.S. students who were deleted for lack of a final event code over 98 percent were still assigned to NSWC at the time the data was obtained. The other two percent simply had incomplete records. Finally, the reduction of the basic file that removed nearly 1,000 records is justified for those portions of the study that might be influenced by the change in the curriculum (as stated earlier, the method for entering some data may have biased the database). Based on the number of records in the basic file, and the reduced form of the basic file there is no reason to suspect that the database was of insufficient size to taint the results.

B. ANALYSIS

1. Attrition Rate Models

Although there appeared to be a significant difference in the graduation rate and the dis-enrollment for voluntary reasons between the students with complete records category and the complete records after 18 September 1990 category, as explained in

Chapter III, this is most likely attributed to the method for entering past data. For this reason the data which should most accurately reflect the true graduate and dis-enrollment percentages contains only records between 18 September 1990 and 24 April 1993.

Clearly, under the training program as it is conducted today an average of approximately 30 percent of students arriving at the command will graduate. Of those that fail to graduate nearly 60 percent are for voluntary reason. Examining the models created to describe attrition rates brings forth three items worthy of note.

First, 27 percent of all trainees reporting to NSWC never begin training. Second, ten percent of all students who voluntarily dis-enroll do so within 14 days of their reporting on board. In many of these cases the individuals have barely finished the check-in procedure. Interviews with some of the individuals who were in this category revealed that they were taking orders to BUD/S in order to avoid other less attractive orders. Finally, 75 percent of all dis-enrollment of students who have begun training occurs by day 38 of training. This translates to the end of "HELLWEEK." These three notes imply the need for a better screening process and / or a modification to the course of instruction. A screening process that should improve the efficiency will be addressed later in this chapter and in the conclusion and recommendations. Modification to the course of instruction that may reduce the cost is based strictly on speculation and will be addressed in the conclusions.

2. Attrition Rate Versus Time On-Board the Command

As shown in Figure 2, over 99 percent of all trainees who are going to begin training do so within 154 days of their arrival at NSWC. This indicates an upper bound, in days, that anyone should be allowed to remain at the command in a pre-training status prior to commencing training. Even at this point, six percent of student salaries could be saved over the current method used.

The simple linear regression used on the weekly graduation rate model strongly suggests that there is a negative correlation between time at NSWC prior to an individual starting training and probability of graduation. When examining only those students who begin training, the highest proportion of those who graduate occurs between day 21 and 42. This unfortunately does not translate well to the model displaying proportion of graduates (Figure 4). At day 42 only 26 percent of those who graduate would have begun training, while by day 77 more than 80 percent would have begun. Figure 5 indicates that the maximum proportion of graduates occurs around day 77 when compared against both students who class-up and those that do not.

Finally, the number of days students require to complete the course once they have begun training was studied. The chart in Figure 12 is a reflection of the data extrapolated from the database. From the figure, it appears that approximately 82 percent of the graduates require one or no roll-backs prior to graduation. This fact will be used later in this chapter when discussing graduation potential given a student is rolled-back.

3. Attrition Rate Versus Class Convening Date

The model attempting to link graduation potential to class convening date fails to produce any significant results. There may be a slight increase in graduation potential during the months from July through October, but the change is so small that a much larger data set would be required to show if it is significant.

4. Graduation Potential Given Student is "Rolled-Back"

This model clearly shows a significantly better potential for graduation given a student is rolled-back post-"HELLWEEK" as opposed to pre-"HELLWEEK." More than a third of pre-"HELLWEEK" set backs that resulted in dis-enrollments where for medical related reasons. This calls for a more in-depth investigation as to the cost effectiveness of the medical rehabilitation program and whether pre-"HELLWEEK" students who are not capable of continuing the program should be retained at the command. The majority of students who were rolled-back after "HELLWEEK" and later dis-enrolled were dropped for performance reasons, most commonly for failing pool competency.

These findings in conjunction with the results of the days required to graduate suggest that students prior to and including "HELLWEEK" be reviewed carefully and if rolled-back they should be allowed only the one opportunity. Students who are post-"HELLWEEK" and are not capable of proceeding at that time to the next stage of training should most likely be rolled-back unless their record indicates otherwise. A possible review process to determine if students should be retained could utilize the logit model, Forecast of Successful Students.

5. Forecast of Successful Students

Conducting an in-depth analysis of the six regression models described in Chapter III and examining the predictions of the models, it is clear that overall the models have approximately the same power when applied to a randomly selected data set. Also of interest is the percentage of students who are predicted not to graduate that do graduate (type I error). This is the main interest to senior NSW officers. Their concern is in eliminating individuals who the model shows will not graduate when they may become outstanding SEAL operators given the opportunity. The percentages for these models can be located in Appendix D. It should be noted that for each of these models the critical value of $P(F = 1)$ will directly affect these percentages. For example, in Table 12, if the critical value for the full logit model is changed from 0.5 to 0.94 the following occurs:

TABLE 12. CHANGE IN VALUE OF CRITICAL $P(F_i=1)$.

	% Correct	% Sensitivity	% Specificity	% False Pos. (Type I Error)	% False Neg. (Type II Error)
$P(Y_i=1)> 0.5$	77.1	92.7	33	20.4	38.4
$P(Y_i=1)> 0.94$	36.6	15	97.4	5.8	71.1

Although the percent correct is greatly reduced and the Type II error is drastically increased, the proportion of Type I error drops to only 5.8 percent. If it is the concern of the policy makers to exclude as few potential students who might be in the Type I category then selecting a higher critical value may prove correct. In this case, if the critical value is set at 0.94 the model could be used to eliminate 155 students, 146 of which would dis-enroll. If this were part of the screening process the PCS cost associated with these students could be avoided.

6. Transfer Date After Dis-enrollment

Clearly, there is a problem with this portion of the training program. A system should be in place which would update NMPC at least weekly on students who have been dis-enrolled from training. Inquiries at NMPC into the amount of time required to transfer personnel once notification of dis-enrollment has been sent, revealed orders can be en-route in less than three working days. Based on this information, the average of almost 53 days prior to being transferred should be reduced to no more than 14 days.

7. Estimated Potential Savings

a. Modification of PCS Orders

Currently, married students who receive orders to BUD/S are permitted to bring their families with them. The author could find no data separating the cost of these moves from the average PCS cost. Since the training course is only six months, which is the length of a typical deployment, an argument can be made to have the students orders modified to be unaccompanied. Upon graduation students will first be stationed at either NAB Little Creek, Virginia or NAB Coronado, California. If a member was originally station on the east coast and is transferred back to the east coast after graduation, moving his family twice in a eight month period is not cost effective.

b. Change in BUD/S Curriculum

Examination of the models pertaining to dis-enrollment rates shows more than 75 percent of all dis-enrollments will occur prior to the end of "HELLWEEK."

Modifications to the course should be explored that could remove these individuals prior to transferring them PCS. One possible solution, which would require major modification to the personnel transfer system, would be to examine the feasibility of conducting the training up through "HELLWEEK" on a TAD basis in two locations, NAB Coronado, California or NAB Little Creek, Virginia. Once a student successfully completed this portion of training he would be transferred PCS unaccompanied to NAB Coronado for the remainder of the BUD/S training.

c. ***Lead Time***

Attempting to choose an optimal lead time to reduce the cost is somewhat subjective since the optimal number of days would preclude most students from completing the course. Therefore, the use of the upper bound is the only concrete guide. Figure 5 suggest 77 days of pre-training should be the maximum. More than 82 percent of the graduates would have begun training within 77 days. This is a conservative estimate since those students who currently are not classing-up by day 77 could still be placed in training and a percentage of those would graduate.

If a sailor were to receive orders that have him arrive three weeks prior to a class convening date, he would have that class and the following class as opportunities to begin training prior to being dis-enrolled. Based on 500 students per year arriving at NSWC and the use of the data used to derive Figure 11, approximately $478,000 in non-productive salaries could be extracted each year which translates to nearly 14,000

man-days of work. This is approximately 44 percent of the salaries spent on students who are in a pre-training status.

d. Use of Prediction Models

As explained in Chapter I, current requirements for entering BUD/S are a relatively easy screening test and an interview. The screening test is not required to be administered by a SEAL and often prospective trainees arriving at NSWC are unable to pass the basic screening test when given by SEALs. Unlike many other communities, BUD/S training does not require a psychological screening test.

The study conducted by Miss Arroyo, referenced in Chapter I, may have some bearing here. In her study, she attempted to predict ten percent of the failures with at least a 95 percent accuracy. This was achieved through the use of a paper and pencil questionnaire. This questionnaire is made up of 292 questions. Most of the answers can be marked on a standard 'A-E' computer graded card.

This questionnaire, or some extension of it, coupled with the logit model developed in this study would likely be able to filter out a minimum of ten percent of the would be trainees who would in fact fail. This screening process would have at least a 95 percent accuracy.

The average moving cost of the PCS orders required to transfer personnel to NSWC is $714.00 per student. If 500 students are currently enrolled in a given year, over $350K in PCS funds will be required. Given ten percent of these students who will fail can be removed prior to issuing orders, approximately $35K in cost will be avoided

annually. This does not account for the salaries of the students who could be screened out nor the man-hours wasted by instructors and the students predicted to fail.

Using the model for all dis-enrollments it can be seen that the median time on board NSWC prior to dis-enrollment is 93 days. This multiplied by the average daily salary of $34.98 per day per student (includes those that never class-up) multiplied by the 50 students per year screened out by the forecast models indicates the Navy could realize an additional $162K of productive salaries or 4,600 man-days of labor per year.

e. *Reduction of Time at NSWC after Dis-enrollment*

The model displaying the amount of time after dis-enrollment prior to a service member being transferred indicates a great deal of inefficiency. Using 500 students as a typical yearly average of the number of students arriving at BUD/S, 70 percent or approximately 350 will dis-enroll. This multiplied by the average non-productive salaries of $1,841.32 per student is approximately $645K per year or 18,400 man-days of work.

V. CONCLUSIONS

Clearly, as discussed in chapter IV, the findings indicate there is potential savings that can be extracted from the NSWC BUD/S training course as it is currently operated. A more in-depth study should be conducted in the following areas:

- Modifying the curriculum in an attempt to remove the majority of the attrites prior to conducting PCS transfers. For example, it may be cost effective to conduct up to and including "HELLWEEK" at a east and west coast location. Once an individual has successfully completed "HELLWEEK" transfer him PCS to Coronado.
- Conduct an analysis of graduates who were rolled-back during pool competency compared to students who were dis-enrolled after being set back during pool competency. Determine if individuals should automatically be rolled-back or dis-enrolled after failing this portion of training.
- The medical rehabilitation program should be closely examined to determine if students who have not successfully completed "HELLWEEK" should be retained if unable to continue with their assigned class.

Recommendations based on the results of this study are expectations and assume that future training will be conducted in the same manner as when the data for this study was collected or modified as this study suggest. Following are the recommendations that should provided savings / benefit to the Navy:

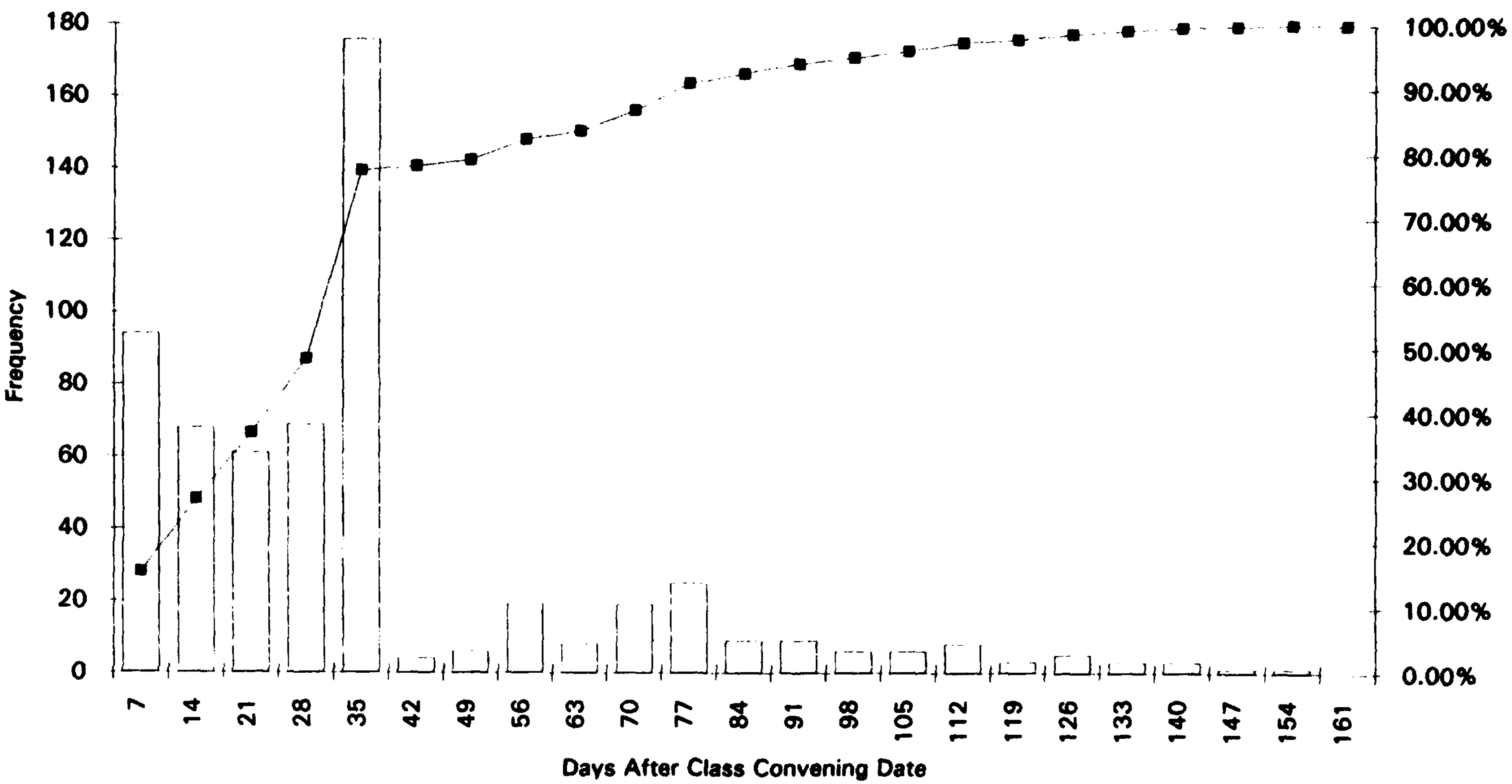
- Implement the logit forecast model using data in student records in conjunction with a psychological profile test developed specifically for the BUD/S program to eliminate a minimum of ten percent of high risk applicants prior to issuing them orders.
- Implement a maximum lead time for all students of approximately 77 days. Ensure that NMPC does not order students into BUD/S more than four weeks prior to a class convening date and ensure that the students understand that they are on a time line for graduation.
- Students who are unable to continue with training prior to "HELLWEEK" are dis-enrolled unless there are extenuating circumstances. If rolled-back prior to "HELLWEEK" they are allowed one opportunity prior to dis-enrollment.
- Implement a process that updates NMPC at least weekly on student attrites in order to reduce non-productive time after dis-enrollment.

This study examined the Basic Underwater Demolition / SEAL training course. This type of study should be conducted on any course in any service that has a historically high attrition rate or high cost associated with its training. Obvious schools / courses that should be reviewed are all services flight training, nuclear power school and all special operation selection processes.

APPENDIX A

Descriptive Statistics for Dis-enrollments

DR		DR ALL		DRA		DRA ALL	
Column 1		Column 1		Column 1		Column 1	
Mean	36.5480315	Mean	105.459381	Mean	47.70731707	Mean	116.1940299
Standard Error	1.164564904	Standard Error	2.31134011	Standard Error	6.225071642	Standard Error	10.85851654
Median	32	Median	93	Median	32	Median	82
Mode	36	Mode	10	Mode	29	Mode	66
Standard Deviation	29.34686729	Standard Deviation	74.32315298	Standard Deviation	39.85980711	Standard Deviation	88.32697379
Variance	861.2386186	Variance	5523.931069	Variance	1588.812195	Variance	7801.249881
Kurtosis	2.289050174	Kurtosis	3.384437744	Kurtosis	-0.086367765	Kurtosis	0.843984869
Skewness	1.544861442	Skewness	1.268864903	Skewness	0.985795087	Skewness	1.1070787
Range	157	Range	652	Range	139	Range	401
Minimum	1	Minimum	0	Minimum	3	Minimum	12
Maximum	158	Maximum	652	Maximum	142	Maximum	413
Sum	23208	Sum	109045	Sum	1956	Sum	7785
Count	635	Count	1034	Count	41	Count	67
DRM		DRM ALL		DRP		DRP ALL	
Column 1		Column 1		Column 1		Column 1	
Mean	28.23728814	Mean	119.0560345	Mean	67.39047619	Mean	170.856
Standard Error	2.534441247	Standard Error	5.498481005	Standard Error	3.662480176	Standard Error	7.05545503
Median	21	Median	107.5	Median	76	Median	168
Mode	17	Mode	101	Mode	32	Mode	146
Standard Deviation	27.53107883	Standard Deviation	83.76529444	Standard Deviation	37.52934627	Standard Deviation	78.88238529
Variance	757.9603071	Variance	7016.624552	Variance	1408.451832	Variance	6222.43071
Kurtosis	2.908041145	Kurtosis	6.482565381	Kurtosis	-0.797951796	Kurtosis	-0.267842846
Skewness	1.88522911	Skewness	1.574802366	Skewness	0.200174476	Skewness	0.595281946
Range	118	Range	652	Range	157	Range	339
Minimum	1	Minimum	0	Minimum	1	Minimum	44
Maximum	119	Maximum	652	Maximum	158	Maximum	383
Sum	3332	Sum	27621	Sum	7076	Sum	21357
Count	118	Count	232	Count	105	Count	125
DRV		DRV ALL					
Column 1		Column 1					
Mean	29.22911051	Mean	85.70819672				
Standard Error	0.912511185	Standard Error	2.302320829				
Median	35	Median	82				
Mode	36	Mode	10				
Standard Deviation	17.57620871	Standard Deviation	56.86312981				
Variance	308.9230422	Variance	3233.415532				
Kurtosis	5.813413916	Kurtosis	0.49501671				
Skewness	1.407743886	Skewness	0.783969084				
Range	127	Range	317				
Minimum	1	Minimum	1				
Maximum	128	Maximum	318				
Sum	10844	Sum	52282				
Count	371	Count	610				



Histogram All Dis-Enrollments

ANALYSIS OF GAMMA DISTRIBUTION FIT FOR ALL DIS-ENROLLMENTS

DATA : X
SELECTION : ALL
X AXIS LABEL : X
SAMPLE SIZE : 635
CENSORING : NONE
FREQUENCIES : 1
EST. METHOD : MAXIMUM LIKELIHOOD
CONF METHOD : ASYMPTOTIC NORMAL APPROXIMATION

		CONF. INTERVALS (95 PERCENT)		COVARIANCE MATRIX OF PARAMETER ESTIMATES	
PARAMETER	ESTIMATE	LOWER	UPPER	ALPHA	BETA
ALPHA	1.6348	1.47	1.7997	0.0070704	-0.096686
BETA	22.356	19.723	24.989	-0.096686	1.8036

LOG LIKELIHOOD FUNCTION AT MLE = -3518.1

	SAMPLE	FITTED
MEAN	: 36.548	36.548
STD DEV	: 29.347	28.584
SKEWNESS	: 1.5412	1.5642
KURTOSIS	: 5.2606	6.6701

* BASED ON MIDPOINTS OF FINITE INTERVALS

PERCENTILES	SAMPLE	FITTED
5:	5	4.9113
10:	8	7.8826
25:	16	15.634
50:	32	29.427
75:	37	49.824
90:	78	74.584
95:	102	92.524

GOODNESS OF FIT TESTS

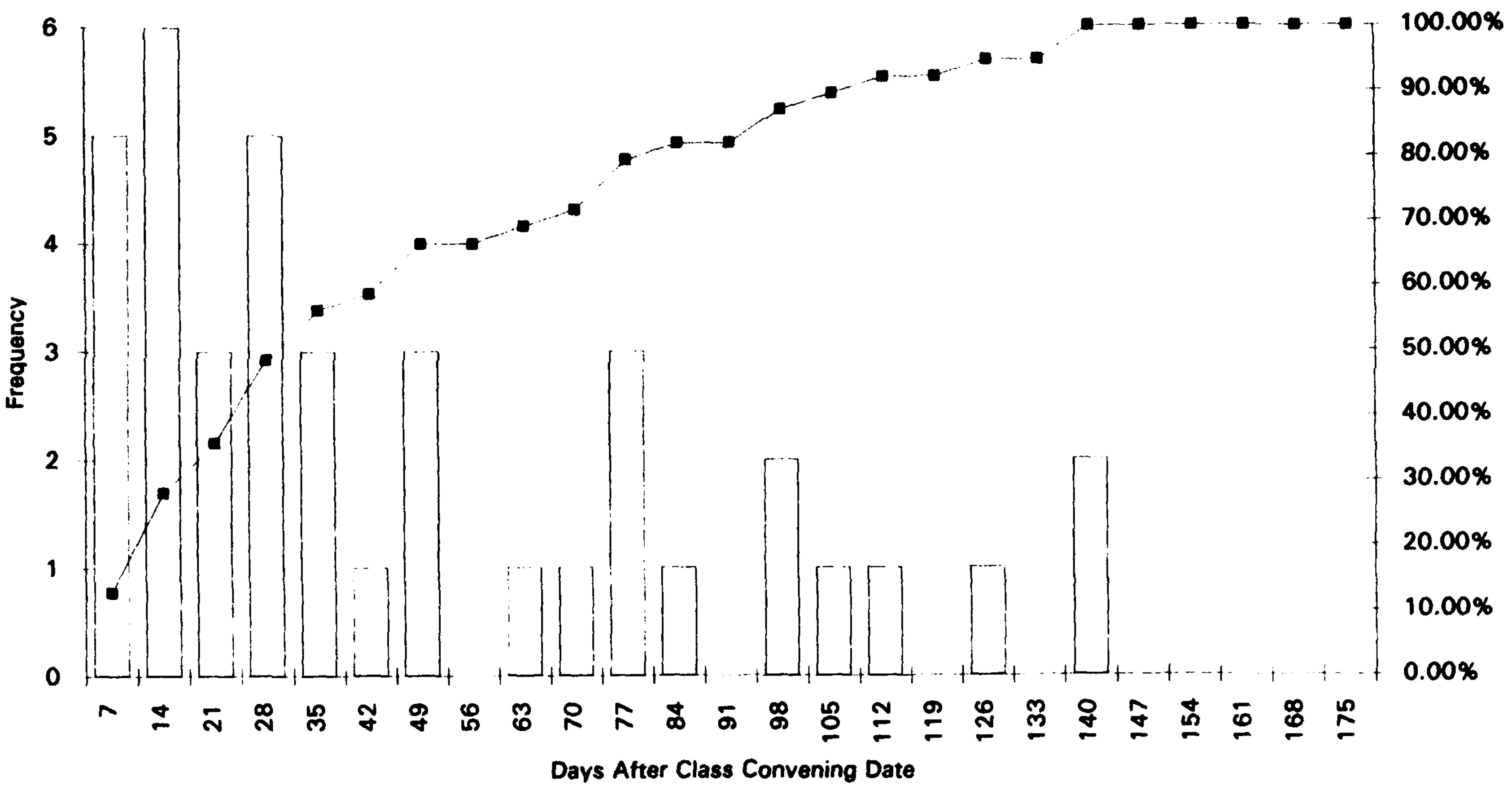
CHI-SQUARE : 174.51
EG FREED: 8
SIGNIF : 0
KOLM-SMIRN : 0.16655
SIGNIF : 1.0036E?15
CRAMER-V M : 1.8462
SIGNIF : < .01
ANDER-DARL : 8.7087
SIGNIF : < .01

KS, AD, AND CV SIGNIF. LEVELS NOT EXACT WITH ESTIMATED PARAMETERS.

NOTE: A SMALL SIGNIFICANCE LEVEL (EG. P?.01) INDICATES LACK OF FIT

CHI-SQUARE GOODNESS OF FIT TABLE

LOWER	UPPER	OBS	EXP	O-E	((O-E)*2)-E
-INF.	14.273	139	141.67	-2.6699	0.050315
14.273	28.545	129	166.85	-37.848	8.5855
28.545	42.818	232	123.36	108.64	95.68
42.818	57.091	23	81.041	-58.041	41.568
57.091	71.364	22	50.327	-28.327	15.944
71.364	85.636	40	30.236	9.7644	3.1533
85.636	99.909	15	17.773	-2.7729	0.43262
99.909	114.18	15	10.287	4.7135	2.1598
114.18	128.45	11	5.8851	5.1149	4.4455
128.45	142.73	6	3.3369	2.6631	2.1253
142.73	+INF.	3	4.2388	-1.2388	0.36206
TOTAL		635	635		174.51



Histogram Administrative Dis-Enrollments

ANALYSIS OF EXPONENTIAL DISTRIBUTION FIT FOR ADMINISTRATIVE DIS-ENROLLMENTS

DATA : X
SELECTION : ALL
X AXIS LABEL : X
SAMPLE SIZE : 41
CENSORING : NONE
FREQUENCIES : 1
EST. METHOD : MAXIMUM LIKELIHOOD
CONF METHOD : EXACT

	CONF. INTERVALS (95 PERCENT)		COVARIANCE MATRIX OF PARAMETER ESTIMATES	
PARAMETER	ESTIMATE	LOWER	UPPER	SIGMA
SIGMA	47.707	35.909	66.491	55.512

LOG LIKELIHOOD FUNCTION AT MLE = -199.47

		SAMPLE	FITTED
MEAN	:	47.707	47.707
STD DEV	:	39.86	47.707
SKEWNESS	:	0.94936	2
KURTOSIS	:	2.781	9

* BASED ON MIDPOINTS OF FINITE INTERVALS

PERCENTILES	SAMPLE	FITTED
5:	8	2.4471
10:	10	5.0265
25:	17	13.725
50:	32	33.068
75:	77	66.136
90:	109	109.85
95:	126	142.92

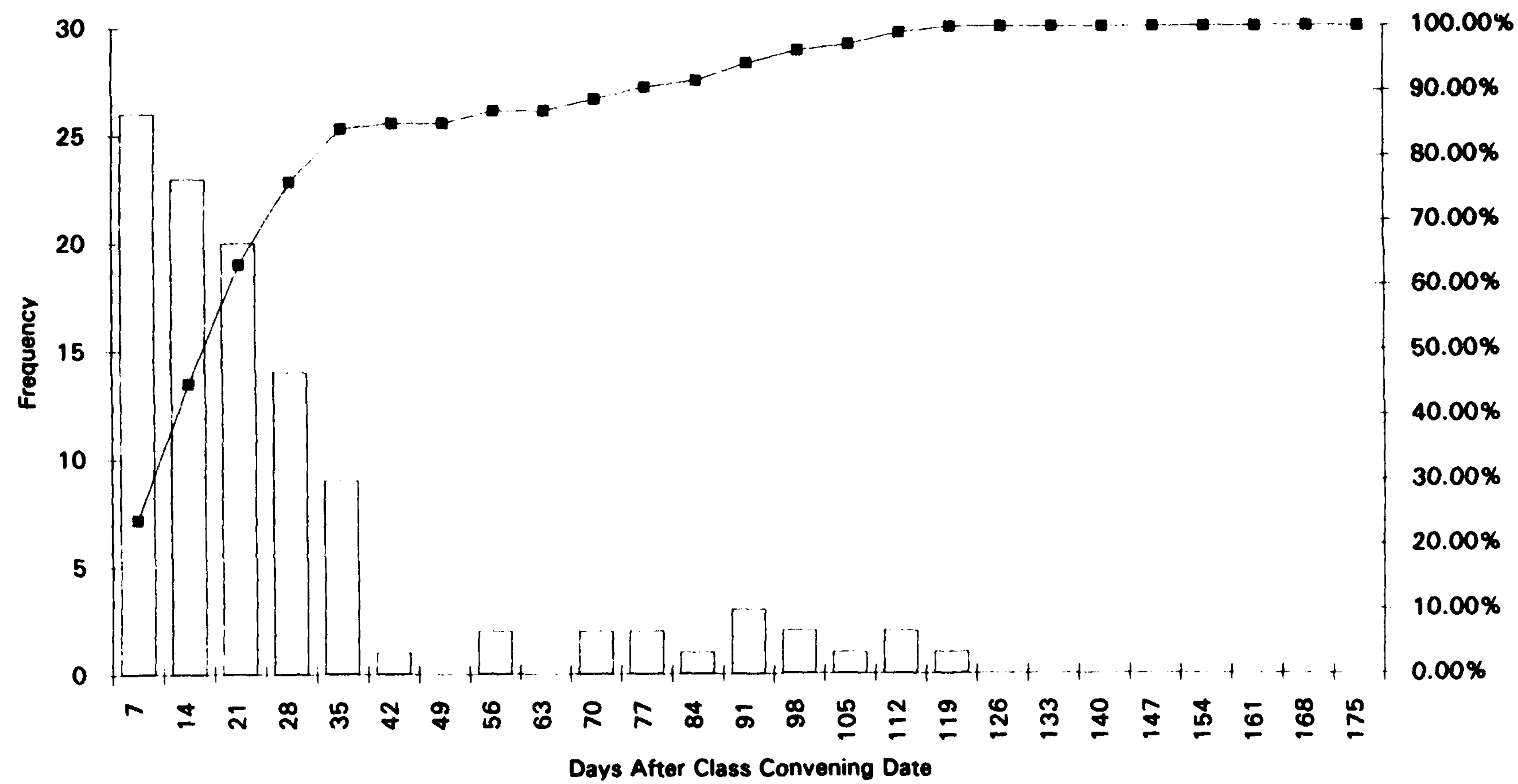
GOODNESS OF FIT TESTS
CHI-SQUARE : 1.4981
DEG FREED: 4
SIGNIF : 0.82698
KOLM-SMIRN : 0.1056
SIGNIF : 0.75042
CRAMER-V M : 0.069783
SIGNIF : >.15
ANDER-DARL : 0.56322
SIGNIF : >.15

KS, AD, AND CV SIGNIF. LEVELS NOT EXACT WITH ESTIMATED PARAMETERS.

NOTE: A SMALL SIGNIFICANCE LEVEL (EG. P?.01) INDICATES LACK OF FIT

CHI-SQUARE GOODNESS OF FIT TABLE

LOWER	UPPER	OBS	EXP	O-E	((O-E)*2)?E
-INF.	19.857	13	13.959	-0.95929	0.065923
19.857	39.714	11	9.2066	1.7934	0.34936
39.714	59.571	4	6.072	-2.072	0.70705
59.571	79.429	5	4.0047	0.99534	0.24739
79.429	119.14	5	4.3831	0.61686	0.086814
119.14	+INF.	3	3.3743	-0.37435	0.041529
TOTAL		41	41		1.4981



Histogram Medical Dis-Enrollments

ANALYSIS OF GAMMA DISTRIBUTION FIT FOR MEDICAL DIS-ENROLLMENTS

DATA : X
SELECTION : ALL
X AXIS LABEL : X SAMPLE SIZE : 118
CENSORING : NONE
FREQUENCIES : 1
EST. METHOD : MAXIMUM LIKELIHOOD
CONF METHOD : ASYMPTOTIC NORMAL APPROXIMATION

	CONF. INTERVALS (95 PERCENT)		COVARIANCE MATRIX OF PARAMETER ESTIMATES		
PARAMETER	ESTIMATE	LOWER	UPPER	ALPHA	BETA
ALPHA	1.3608	1.0465	1.6752	0.025707	-0.39198
BETA	20.75	14.981	26.518	-0.39198	8.6581

LOG LIKELIHOOD FUNCTION AT MLE = -627.79

	SAMPLE	FITTED
MEAN	: 28.237	28.237
STD DEV	: 27.531	24.206
SKEWNESS	: 1.8612	1.7145
KURTOSIS	: 5.7339	7.409

* BASED ON MIDPOINTS OF FINITE INTERVALS

GOODNESS OF FIT TESTS

CHI-SQUARE : 23.952
DEG FREED: 4
SIGNIF : 0.000081681
KOLM-SMIRN : 0.10968
SIGNIF : 0.11693
CRAMER-V M : 0.29573
SIGNIF : < .15
ANDER-DARL : 1.8841
SIGNIF : < .15

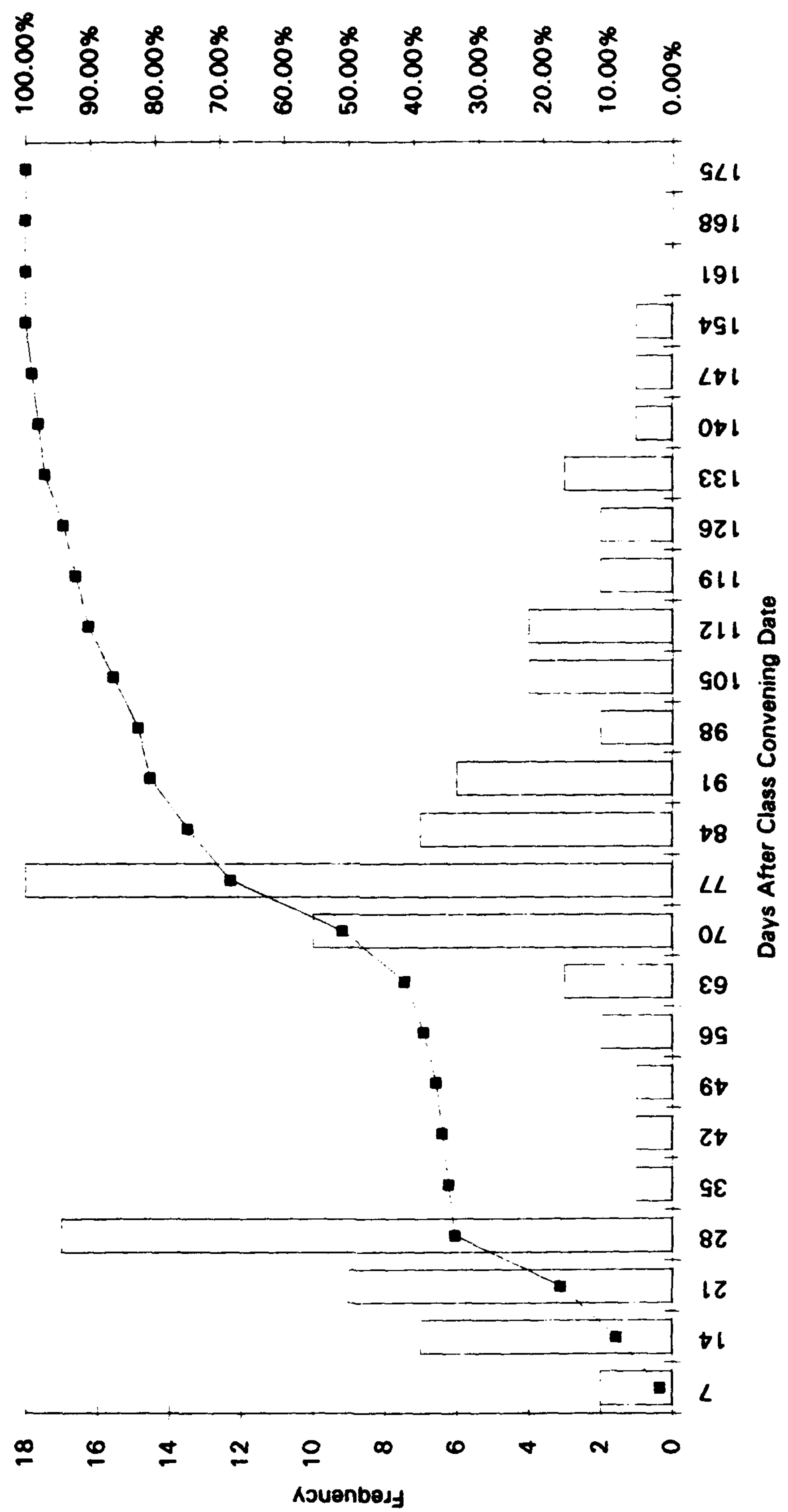
PERCENTILES	SAMPLE	FITTED
5:	4	2.7963
10:	7	4.8494
25:	10	10.643
50:	21	21.701
75:	32	38.843
90:	77	60.261
95:	101	76.011

KS, AD, AND CV SIGNIF. LEVELS NOT EXACT WITH ESTIMATED PARAMETERS.

NOTE: A SMALL SIGNIFICANCE LEVEL (EG. P?.01) INDICATES LACK OF FIT

CHI-SQUARE GOODNESS OF FIT TABLE

LOWER	UPPER	OBS	EXP	O-E	((O-E)*2)?E
INF.	14.75	39	41.405	-2.4047	0.13965
14.75	29.5	46	33.272	12.728	4.869
29.5	44.25	16	19.826	-3.8258	0.73828
44.25	59	2	11.032	-9.032	7.3946
59	73.75	3	5.9436	-2.9436	1.4578
73.75	88.5	3	3.1421	-0.14214	0.0064299
88.5	+INF.	9	3.3797	5.6203	9.3462
TOTAL		118	118		23.952



Histogram Performance Dis-Enrollments

ANALYSIS OF GAMMA DISTRIBUTION FIT FOR PERFORMANCE DIS-ENROLLMENTS

DATA : X
SELECTION : ALL
X AXIS LABEL : X
SAMPLE SIZE : 105
CENSORING : NONE
FREQUENCIES : 1
EST. METHOD : MAXIMUM LIKELIHOOD
CONF METHOD : ASYMPTOTIC NORMAL APPROXIMATION

		CONF. INTERVALS (95 PERCENT)		COVARIANCE MATRIX OF PARAMETER ESTIMATES	
PARAMETER	ESTIMATE	LOWER	UPPER	ALPHA	BETA
ALPHA	2.3804	1.776	2.9847	0.095042	-1.1304
BETA	28.311	20.311	36.311	-1.1304	16.651

LOG LIKELIHOOD FUNCTION AT MLE = -634.8

	SAMPLE	FITTED
MEAN	: 67.39	67.39
STD DEV	: 37.529	43.679
SKEWNESS	: 0.1973	1.2963
KURTOSIS	: 2.183	5.5206

* BASED ON MIDPOINTS OF FINITE INTERVALS

PERCENTILES	SAMPLE	FITTED
5:	17	14.657
10:	21	20.874
25:	32	35.271
50:	76	58.226
75:	90	89.627
90:	118	125.88
95:	134	151.44

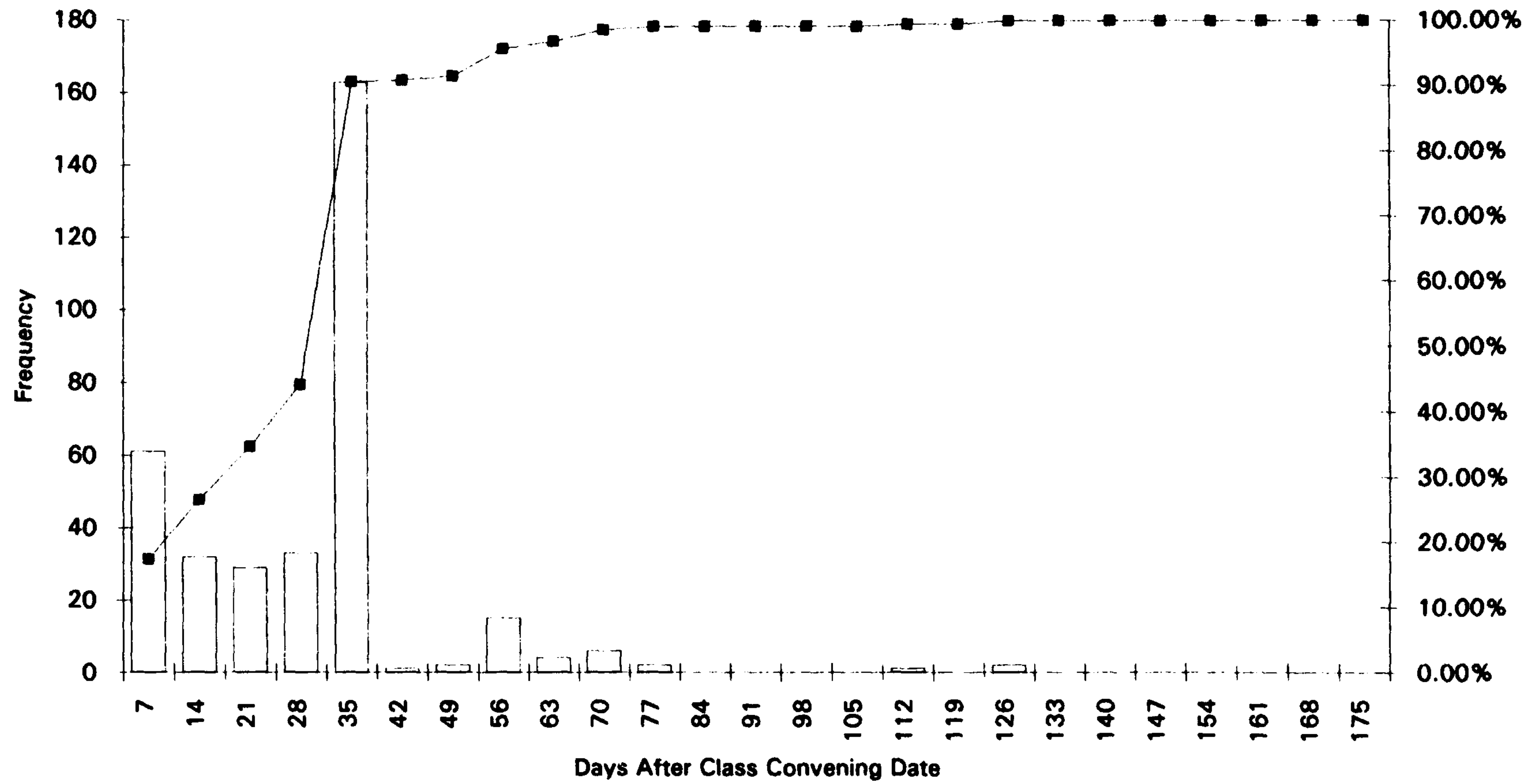
GOODNESS OF FIT TESTS
CHI-SQUARE : 33.398
DEG FREED: 6
SIGNIF : 0.0000087893
KOLM-SMIRN : 0.18972
SIGNIF : 0.0010429
CRAMER-V M : 0.65367
SIGNIF : < .025
ANDER-DARL : 3.117
SIGNIF : < .025

KS, AD, AND CV SIGNIF. LEVELS NOT EXACT WITH ESTIMATED PARAMETERS.

NOTE: A SMALL SIGNIFICANCE LEVEL (EG. P?.01) INDICATES LACK OF FIT

CHI-SQUARE GOODNESS OF FIT TABLE

LOWER	UPPER	OBS	EXP	O-E	((O-E)*2)?E
-INF.	19.625	10	9.337	0.66299	0.047076
19.625	39.25	27	21.624	5.3763	1.3367
39.25	58.875	2	22.217	-20.217	18.397
58.875	78.5	27	17.807	9.1931	4.7461
78.5	98.125	20	12.65	7.3497	4.2702
98.125	117.75	8	8.3675	-0.36752	0.016142
117.75	137.38	8	5.2793	2.7207	1.4022
137.38	157	2	3.2208	-1.2208	0.46273
157	+INF.	1	4.4974	-3.4974	2.7197
TOTAL		105	105		33.398



Histogram Voluntary Dis-Enrollments

ANALYSIS OF GAMMA DISTRIBUTION FIT FOR VOLUNTARY DIS-ENROLLMENTS

DATA : X
SELECTION : ALL
X AXIS LABEL : X
SAMPLE SIZE : 371
CENSORING : NONE
FREQUENCIES : 1
EST. METHOD : MAXIMUM LIKELIHOOD
CONF METHOD : ASYMPTOTIC NORMAL APPROXIMATION

		CONF. INTERVALS (95 PERCENT)		COVARIANCE MATRIX OF PARAMETER ESTIMATES	
PARAMETER	ESTIMATE	LOWER	UPPER	ALPHA	BETA
ALPHA	2.2908	1.9821	2.5996	0.024805	-0.13816
BETA	12.759	10.837	14.681	-0.13816	0.96105

LOG LIKELIHOOD FUNCTION AT MLE = -1936.9

	SAMPLE	FITTED
MEAN	: 29.229	29.229
STD DEV	: 17.576	19.312
SKEWNESS	: 1.402	1.3214
KURTOSIS	: 8.7192	5.6192

* BASED ON MIDPOINTS OF FINITE INTERVALS

PERCENTILES	SAMPLE	FITTED
5:	4	6.0963
10:	8	8.7715
25:	15	15.03
50:	35	25.104
75:	36	38.982
90:	37	55.081
95:	56	66.458

GOODNESS OF FIT TESTS
CHI-SQUARE : 223.48
DEG FREED: 5
SIGNIF : 0
KOLM-SMIRN : 0.21975
SIGNIF : 5.4909E?16
CRAMER-V M : 3.8756
SIGNIF : < .01
ANDER-DARL : 18.867
SIGNIF : < .01

KS, AD, AND CV SIGNIF. LEVELS NOT EXACT WITH ESTIMATED PARAMETERS.

NOTE: A SMALL SIGNIFICANCE LEVEL (EG. P?.01) INDICATES LACK OF FIT

CHI-SQUARE GOODNESS OF FIT TABLE

LOWER	UPPER	OBS	EXP	O-E	((O-E)*2)?E
INF.	12.7	81	70.853	10.147	1.4531
12.7	25.4	61	117.12	-56.124	26.894
25.4	38.1	196	85.785	110.22	141.6
38.1	50.8	14	9.498	-48.498	47.518
50.8	63.5	17	25.465	-8.465	2.8139
63.5	76.2	10	12.244	-2.2442	0.41133
76.2	88.9	2	5.6304	-3.6304	2.3408
88.9	+INF.	3	4.4006	-1.4006	0.44578
TOTAL		371	371		223.48

APPENDIX B

Days (i)	# GRD (g_i)	$\Sigma_{i=14}^{i} g_i$	# DR (dc_i)	$\Sigma_{i=14}^{i} dc_i$	# CLU (t_i)	$\Sigma_{i=14}^{i} t_i$	# DH (dh_i)	$\Sigma_{i=14}^{i} dh_i$	Total (p_i)	$\Sigma_{i=14}^{i} p_i$
14	3	3	5	5	8	8	79	79	87	87
21	22	25	11	16	33	41	37	116	70	157
28	21	46	16	32	37	78	34	150	71	228
35	30	76	20	52	50	128	27	177	77	305
42	32	108	34	86	66	194	18	195	84	389
49	34	142	62	148	96	290	19	214	115	504
56	67	209	78	226	145	435	27	241	172	676
63	44	253	74	300	118	553	17	258	135	811
70	53	306	84	384	137	690	18	276	155	966
77	38	344	50	434	88	778	20	296	108	1,074
84	16	360	37	471	53	831	15	[illegible]	68	1,142
91	26	386	39	510	65	896	12	323	77	1,219
98	5	391	22	532	27	923	7	330	34	1,253
105	6	397	26	558	32	955	15	345	47	1,300
112	7	404	27	585	34	989	10	355	44	1,344
119	5	409	8	593	13	1,002	4	359	17	1,361
126	6	415	8	601	14	1,016	5	364	19	1,380
133	3	418	7	608	10	1,026	5	369	15	1,395
140	1	419	13	621	14	1,040	6	375	20	1,415
147	0	419	5	626	5	1,045	4	379	9	1,424
154	0	419	5	631	5	1,050	2	381	7	1,431
161	0	419	3	634	3	1,053	2	383	5	1,436
168	0	419	1	635	1	1,054	1	384	2	1,438
175	0	419	0	635	0	1,054	1	385	1	1,439
182	1	420	3	638	4	1,058	2	387	6	1,445
189	0	420	0	638	0	1,058	1	388	1	1,446
196	0	420	0	638	0	1,058	1	389	1	1,447
203	0	420	0	638	0	1,058	0	389	0	1,447
210	0	420	0	638	0	1,058	1	390	1	1,448
217	0	420	0	638	0	1,058	0	390	0	1,448
224	0	420	0	638	0	1,058	1	391	1	1,449

Days (i)	#GRD (g_i)	$\Sigma_{i=14}^{i} g_i$	# DR (dc_i)	$\Sigma_{i=14}^{i} dc_i$	# CLU (t_i)	$\Sigma_{i=14}^{i} t_i$	# DH (dh_i)	$\Sigma_{i=14}^{i} dh_i$	Total (p_i)	$\Sigma_{i=14}^{i} p_i$
231	0	420	0	638	0	1,058	0	391	0	1,449
238	0	420	1	639	1	1,059	0	391	1	1,450
245	0	420	0	639	0	1,059	1	392	1	1,451
252	0	420	1	640	1	1,060	0	392	1	1,452
259	0	420	0	640	0	1,060	0	392	0	1,452
266	0	420	0	640	0	1,060	1	393	1	1,453
273	0	420	0	640	0	1,060	0	393	0	1,453
280	0	420	0	640	0	1,060	1	394	1	1,454
287	0	420	0	640	0	1,060	0	394	0	1,454
294	1	421	0	640	1	1,061	0	394	1	1,455
301	0	421	0	640	0	1,061	0	394	0	1,455
308	0	421	0	640	0	1,061	0	394	0	1,455
315	0	421	0	640	0	1,061	1	395	1	1,456
322	0	421	0	640	0	1,061	0	395	0	1,456
329	0	421	0	640	0	1,061	0	395	0	1,456
336	0	421	0	640	0	1,061	0	395	0	1,456
343	0	421	0	640	0	1,061	0	395	0	1,456
350	0	421	0	640	0	1,061	0	395	0	1,456
357	0	421	0	640	0	1,061	0	395	0	1,456
364	0	421	0	640	0	1,061	0	395	0	1,456
371	0	421	0	640	0	1,061	0	395	0	1,456
378	0	421	0	640	0	1,061	0	395	0	1,456
385	0	421	0	640	0	1,061	0	395	0	1,456
392	0	421	0	640	0	1,061	0	395	0	1,456
399	0	421	0	640	0	1,061	0	395	0	1,456
406	0	421	0	640	0	1,061	0	395	0	1,456
413	0	421	0	640	0	1,061	0	395	0	1,456
420	0	421	0	640	0	1,061	0	395	0	1,456
427	1	422	0	640	1	1,062	0	395	1	1,457
Total	422		640		1,062		395		1,457	

APPENDIX C

Attrition Rate Versus Class Convening Date

	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	
	JUL	AUG	OCT	NOV	JAN	MAR	APR	JUN	JUL	SEP	OCT	DEC	FEB	APR	MAY	JUL	SEP	OCT	DEC	FEB	APR	JUN	AUG	SEP	NOV	
DRA	0	0	0	1	0	0	2	0	1	3	2	2	3	0	5	5	2	1	3	0	2	3	9	0	1	45
DRM	3	3	4	4	8	3	8	6	11	5	3	6	3	11	7	13	9	5	3	3	9	14	11	8	5	164
DRP	1	3	4	2	2	2	4	1	3	3	2	3	4	2	6	18	5	10	3	11	10	16	6	3	4	128
DRV	12	9	12	10	5	15	31	12	9	10	19	13	19	23	20	30	20	7	26	26	37	32	30	20	28	475
DRT	16	15	20	17	15	20	45	19	24	21	26	23	29	36	38	66	36	23	35	40	58	65	56	31	38	812
GRD	22	7	12	22	12	4	37	29	26	38	30	27	27	34	37	38	44	39	15	32	37	42	27	23	8	669
TOT	38	22	32	39	27	24	82	48	50	59	56	50	56	70	75	104	80	62	50	72	95	107	83	54	46	1481
DRA%	0	0	0	0.03	0	0	0.02	0	0.02	0.05	0.04	0.04	0.05	0	0.07	0.05	0.03	0.02	0.06	0	0.02	0.03	0.11	0	0.02	0.03
DRM%	0.08	0.14	0.13	0.1	0.3	0.13	0.1	0.13	0.22	0.08	0.05	0.1	0.05	0.16	0.09	0.13	0.11	0.08	0.06	0.04	0.09	0.13	0.13	0.15	0.11	0.11
DRP%	0.03	0.14	0.13	0.05	0.07	0.08	0.05	0.02	0.06	0.05	0.04	0.06	0.07	0.03	0.08	0.17	0.06	0.16	0.06	0.15	0.11	0.15	0.07	0.06	0.09	0.09
DRV%	0.32	0.41	0.38	0.26	0.19	0.63	0.38	0.25	0.18	0.17	0.34	0.26	0.34	0.33	0.27	0.29	0.25	0.11	0.52	0.36	0.39	0.3	0.36	0.37	0.61	0.32
DRT%	0.42	0.68	0.63	0.44	0.56	0.83	0.55	0.4	0.48	0.36	0.46	0.46	0.52	0.51	0.51	0.63	0.45	0.37	0.7	0.56	0.61	0.61	0.67	0.57	0.83	0.55
GRD%	0.58	0.32	0.38	0.56	0.44	0.17	0.45	0.6	0.52	0.64	0.54	0.54	0.48	0.49	0.49	0.37	0.55	0.63	0.3	0.44	0.39	0.39	0.33	0.43	0.17	0.45
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC														
	0.44	0.48	0.17	0.45	0.49	0.6	0.58	0.32	0.64	0.38	0.56	0.54														
		0.44		0.49		0.39	0.52	0.33	0.55	0.64	0.17	0.3														
				0.39			0.37		0.43	0.63																
AVE	0.45	0.45	0.46	0.46	0.45	0.45	0.45	0.45	0.45	0.45	0.46	0.45														

APPENDIX D

The SAS System 1
13:22 Saturday, February 5, 1994

The LOGISTIC Procedure

Data Set: WORK.MIKE
Response Variable: GRD1
Response Levels: 2
Number of Observations: 95
Link Function: Logit

Response Profile

Ordered Value	GRD1	Count
1	0	27
2	1	68

Criteria for Assessing Model Fit

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	115.408	110.962	.
SC	117.962	126.285	.
-2 LOG L	113.408	98.962	14 [illegible] with 5 DF (p=0.0130)
Score	.	.	14 [illegible] with 5 DF (p=0.0105)

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-13.9721	5.1847	7.2624	0.0070	.	0.000
PAY2	1	-0.8604	0.5763	2.2285	0.1355	-0.362172	0.423
RES3	1	0.2797	0.8266	0.1145	0.7350	0.058024	1.323
AGE4	1	0.5523	0.2090	6.9840	0.0082	0.747485	1.737
MAR5	1	-0.1516	0.8444	0.0322	0.8576	-0.026878	0.859
BF6	1	0.0876	0.0725	1.4593	0.2270	0.199316	1.092

Association of Predicted Probabilities and Observed Responses

Concordant	= 74.7%	Somers' D	= 0.499
Discordant	= 24.8%	Gamma	= 0.502
Tied	= 0.5%	Tau-a	= 0.205
(1836 pairs)		c	= 0.749

The LOGISTIC Procedure

Classification Table

	Correct		Incorrect		Percentages				
Prob Level	Event	Non-Event	Event	Non-Event	Correct	Sensi-tivity	Speci-ficity	False POS	False NEG
0.040	27	0	68	0	28.4	100.0	0.0	71.6	.
0.060	25	0	68	2	26.3	92.6	0.0	73.1	100.0
0.080	25	1	67	2	27.4	92.6	1.5	72.8	66.7
0.100	25	3	65	2	29.5	92.6	4.4	72.2	40.0
0.120	25	4	64	2	30.5	92.6	5.9	71.9	33.3
0.140	24	10	58	3	35.8	88.9	14.7	70.7	23.1
0.160	23	14	54	4	38.9	85.2	20.6	70.1	22.2
0.180	21	19	49	6	42.1	77.8	27.9	70.0	24.0
0.200	21	30	38	6	53.7	77.8	44.1	64.4	16.7
0.220	19	40	28	8	62.1	70.4	58.8	59.6	16.7
0.240	18	48	20	9	69.5	66.7	70.6	52.6	15.8
0.260	16	51	17	11	70.5	59.3	75.0	51.5	17.7
0.280	15	52	16	12	70.5	55.6	76.5	51.6	18.8
0.300	14	54	14	13	71.6	51.9	79.4	50.0	19.4
0.320	12	54	14	15	69.5	44.4	79.4	53.8	21.7
0.340	12	55	13	15	70.5	44.4	80.9	52.0	21.4
0.360	11	57	11	16	71.6	40.7	83.8	50.0	21.9
0.380	10	60	8	17	73.7	37.0	88.2	44.4	22.1
0.400	9	62	6	18	74.7	33.3	91.2	40.0	22.5
0.420	9	62	6	18	74.7	33.3	91.2	40.0	22.5
0.440	9	62	6	18	74.7	33.3	91.2	40.0	22.5
0.460	7	63	5	20	73.7	25.9	92.6	41.7	24.1
0.480	7	63	5	20	73.7	25.9	92.6	41.7	24.1
0.500	6	63	5	21	72.6	22.2	92.6	45.5	25.0
0.520	6	63	5	21	72.6	22.2	92.6	45.5	25.0
0.540	6	63	5	21	72.6	22.2	92.6	45.5	25.0
0.560	4	63	5	23	70.5	14.8	92.6	55.6	26.7
0.580	4	63	5	23	70.5	14.8	92.6	55.6	26.7
0.600	4	63	5	23	70.5	14.8	92.6	55.6	26.7
0.620	3	63	5	24	69.5	11.1	92.6	62.5	27.6
0.640	2	63	5	25	68.4	7.4	92.6	71.4	28.4
0.660	2	63	5	25	68.4	7.4	92.6	71.4	28.4
0.680	2	64	4	25	69.5	7.4	94.1	66.7	28.1
0.700	2	64	4	25	69.5	7.4	94.1	66.7	28.1
0.720	1	65	3	26	69.5	3.7	95.6	75.0	28.6
0.740	1	65	3	26	69.5	3.7	95.6	75.0	28.6
0.760	1	65	3	26	69.5	3.7	95.6	75.0	28.6
0.780	1	65	3	26	69.5	3.7	95.6	75.0	28.6
0.800	1	65	3	26	69.5	3.7	95.6	75.0	28.6
0.820	1	66	2	26	70.5	3.7	97.1	66.7	28.3
0.840	1	66	2	26	70.5	3.7	97.1	66.7	28.3
0.860	1	67	1	26	71.6	3.7	98.5	50.0	28.0
0.880	1	67	1	26	71.6	3.7	98.5	50.0	28.0
0.900	0	67	1	27	70.5	0.0	98.5	100.0	28.7
0.920	0	68	0	27	71.6	0.0	100.0	.	28.4

The LOGISTIC Procedure

Data Set: WORK.MIKE
Response Variable: GRD1
Response Levels: 2
Number of Observations: 95
Link Function: Logit

Response Profile

Ordered Value	GRD1	Count
1	0	27
2	1	68

Stepwise Selection Procedure

Step 0. Intercept entered:

Residual Chi-Square = 14.9581 with 5 DF (p=0.0105)

Step 1. Variable AGE4 entered:

Criteria for Assessing Model Fit

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	115.408	105.841	.
SC	117.962	110.949	.
-2 LOG L	113.408	101.841	11.568 with 1 DF (p=0.0007)
Score	.	.	12.206 with 1 DF (p=0.0005)

Residual Chi-Square = 2.7532 with 4 DF (p=0.5999)

Step 2. Variable PAY2 entered:

Criteria for Assessing Model Fit

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	115.408	106.566	.
SC	117.962	114.227	.
-2 LOG L	113.408	100.566	12.843 with 2 DF (p=0.0016)
Score	.	.	13.620 with 2 DF (p=0.0011)

Step 3. Variable PAY2 is removed:

Criteria for Assessing Model Fit

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	115.408	105.841	.
SC	117.962	110.949	.
-2 LOG L	113.408	101.841	11.568 with 1 DF (p=0.0007)
Score	.	.	12.206 with 1 DF (p=0.0005)

NOTE: Model building terminates because the last variable entered is removed by the Wald statistic criterion.

Summary of Stepwise Procedure

	Variable		Number	Score	Wald	Pr >
Step	Entered	Removed	In	Chi-Square	Chi-Square	Chi-Square
1	AGE4		1	12.2058	.	0.0005
2	PAY2		2	1.2317	.	0.2671
3		PAY2	1	.	1.2030	0.2727

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-8.5853	2.4190	12.5957	0.0004	.	0.000
AGE4	1	0.3143	0.0981	10.2589	0.0014	0.425299	1.369

Association of Predicted Probabilities and Observed Responses

Concordant	= 72.7%	Somers' D	= 0.460
Discordant	= 26.7%	Gamma	= 0.463
Tied	= 0.7%	Tau-a	= 0.189
(1836 pairs)		c	= 0.730

Classification Table

	Correct		Incorrect		Percentages				
Prob Level	Event	Non-Event	Event	Non-Event	Correct	Sensi-tivity	Speci-ficity	False POS	False NEG
0.140	27	0	68	0	28.4	100.0	0.0	71.6	.
0.160	24	11	57	3	36.8	88.9	16.2	70.4	21.4
0.180	22	25	43	5	49.5	81.5	36.8	66.2	16.7
0.200	19	37	31	8	58.9	70.4	54.4	62.0	17.8
0.220	17	44	24	10	64.2	63.0	64.7	58.5	18.5
0.240	16	48	20	11	67.4	59.3	70.6	55.6	18.6
0.260	16	49	19	11	68.4	59.3	72.1	54.3	18.3
0.280	15	51	17	12	69.5	55.6	75.0	53.1	19.0
0.300	15	53	15	12	71.6	55.6	77.9	50.0	18.5
0.320	13	53	15	14	69.5	48.1	77.9	53.6	20.9
0.340	13	54	14	14	70.5	48.1	79.4	51.9	20.6
0.360	13	54	14	14	70.5	48.1	79.4	51.9	20.6
0.380	13	57	11	14	73.7	48.1	83.8	45.8	19.7
0.400	11	61	7	16	75.8	40.7	89.7	38.9	20.8
0.420	9	62	6	18	74.7	33.3	91.2	40.0	22.5
0.440	7	63	5	20	73.7	25.9	92.6	41.7	24.1
0.460	7	63	5	20	73.7	25.9	92.6	41.7	24.1
0.480	7	63	5	20	73.7	25.9	92.6	41.7	24.1
0.500	6	63	5	21	72.6	22.2	92.6	45.5	25.0
0.520	6	64	4	21	73.7	22.2	94.1	40.0	24.7
0.540	6	64	4	21	73.7	22.2	94.1	40.0	24.7
0.560	6	64	4	21	73.7	22.2	94.1	40.0	24.7
0.580	5	64	4	22	72.6	18.5	94.1	44.4	25.6
0.600	3	65	3	24	71.6	11.1	95.6	50.0	27.0
0.620	2	65	3	25	70.5	7.4	95.6	60.0	27.8
0.640	2	65	3	25	70.5	7.4	95.6	60.0	27.8
0.660	2	65	3	25	70.5	7.4	95.6	60.0	27.8
0.680	2	65	3	25	70.5	7.4	95.6	60.0	27.8
0.700	2	66	2	25	71.6	7.4	97.1	50.0	27.5
0.720	2	66	2	25	71.6	7.4	97.1	50.0	27.5
0.740	2	66	2	25	71.6	7.4	97.1	50.0	27.5
0.760	2	66	2	25	71.6	7.4	97.1	50.0	27.5
0.780	1	67	1	26	71.6	3.7	98.5	50.0	28.0
0.800	0	68	0	27	71.6	0.0	100.0	.	28.4

The LOGISTIC Procedure

Data Set: WORK.MIKE
Response Variable: GRD1
Response Levels: 2
Number of Observations: 1317
Link Function: Logit

Response Profile

Ordered Value	GRD1	Count
1	0	972
2	1	345

Criteria for Assessing Model Fit

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	1516.803	1273.773	.
SC	1521.986	1335.970	.
-2 LOG L	1514.803	1249.773	265.030 with 11 DF (p=0.0001)
Score	.	.	232.430 with 11 DF (p=0.0001)

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	2.1909	1.4123	2.4066	0.1208	.	8.944
PAY2	1	-1.0834	0.0897	145.9208	0.0001	-0.704976	0.338
RES3	1	1.0256	0.4920	4.3446	0.0371	0.074094	2.789
DIVE4	1	0.3897	0.1684	5.3546	0.0207	0.105089	1.476
EAOS5	1	-0.4847	0.0805	36.2764	0.0001	-0.306379	0.616
VE6	1	-0.0329	0.0365	0.8134	0.3671	-0.065374	0.968
AR7	1	0.00152	0.0147	0.0107	0.9174	0.004584	1.002
WK8	1	0.0467	0.0334	1.9505	0.1625	0.104599	1.048
MC9	1	-0.0453	0.0132	11.8483	0.0006	-0.158472	0.956
AGE10	1	0.1695	0.0339	24.9607	0.0001	0.267531	1.185
MAR11	1	-0.6130	0.2115	8.3986	0.0038	-0.127920	0.542
BF12	1	0.1231	0.0204	36.4251	0.0001	0.238920	1.131

Association of Predicted Probabilities and Observed Responses

Concordant	= 77.9%	Somers' D	= 0.560
Discordant	= 21.9%	Gamma	= 0.561
Tied	= 0.2%	Tau-a	= 0.217
(335340 pairs)		c	= 0.780

Classification Table

Prob Level	Correct Event	Correct Non-Event	Incorrect Event	Incorrect Non-Event	Percentages Correct	Sensi-tivity	Speci-ficity	False POS	False NEG
0.060	972	0	345	0	73.8	100.0	0.0	26.2	.
0.080	972	2	343	0	74.0	100.0	0.6	26.1	0.0
0.100	972	3	342	0	74.0	100.0	0.9	26.0	0.0
0.120	972	4	341	0	74.1	100.0	1.2	26.0	0.0
0.140	971	6	339	1	74.2	99.9	1.7	25.9	14.3
0.160	971	11	334	1	74.6	99.9	3.2	25.6	8.3
0.180	971	14	331	1	74.8	99.9	4.1	25.4	6.7
0.200	969	17	328	3	74.9	99.7	4.9	25.3	15.0
0.220	966	19	326	6	74.8	99.4	5.5	25.2	24.0
0.240	966	21	324	6	74.9	99.4	6.1	25.1	22.2
0.260	962	24	321	10	74.9	99.0	7.0	25.0	29.4
0.280	960	24	321	12	74.7	98.8	7.0	25.1	33.3
0.300	960	29	316	12	75.1	98.8	8.4	24.8	29.3
0.320	958	38	307	14	75.6	98.6	11.0	24.3	26.9
0.340	953	39	306	19	75.3	98.0	11.3	24.3	32.8
0.360	949	44	301	23	75.4	97.6	12.8	24.1	34.3
0.380	947	55	290	25	76.1	97.4	15.9	23.4	31.3
0.400	943	63	282	29	76.4	97.0	18.3	23.0	31.5
0.420	940	70	275	32	76.7	96.7	20.3	22.6	31.4
0.440	933	74	271	39	76.5	96.0	21.4	22.5	34.5
0.460	918	88	257	54	76.4	94.4	25.5	21.9	38.0
0.480	910	101	244	62	76.8	93.6	29.3	21.1	38.0
0.500	901	114	231	71	77.1	92.7	33.0	20.4	38.4
0.520	886	123	222	86	76.6	91.2	35.7	20.0	41.1
0.540	875	136	209	97	76.8	90.0	39.4	19.3	41.6
0.560	865	153	192	107	77.3	89.0	44.3	18.2	41.2
0.580	847	164	181	125	76.8	87.1	47.5	17.6	43.3
0.600	831	176	169	141	76.5	85.5	51.0	16.9	44.5
0.620	819	192	153	153	76.8	84.3	55.7	15.7	44.3
0.640	802	200	145	170	76.1	82.5	58.0	15.3	45.9
0.660	783	205	140	189	75.0	80.6	59.4	15.2	48.0
0.680	761	212	133	211	73.9	78.3	61.4	14.9	49.9
0.700	738	220	125	234	72.7	75.9	63.8	14.5	51.5
0.720	715	230	115	257	71.8	73.6	66.7	13.9	52.8
0.740	682	243	102	290	70.2	70.2	70.4	13.0	54.4
0.760	654	253	92	318	68.9	67.3	73.3	12.3	55.7
0.780	616	264	81	356	66.8	63.4	76.5	11.6	57.4
0.800	574	274	71	398	64.4	59.1	79.4	11.0	59.2
0.820	529	283	62	443	61.7	54.4	82.0	10.5	61.0
0.840	467	297	48	505	58.0	48.0	86.1	9.3	63.0
0.860	413	306	39	559	54.6	42.5	88.7	8.6	64.6
0.880	337	313	32	635	49.4	34.7	90.7	8.7	67.0
0.900	271	319	26	701	44.8	27.9	92.5	8.8	68.7
0.920	216	330	15	756	41.5	22.2	95.7	6.5	69.6
0.940	148	337	8	824	36.8	15.2	97.7	5.1	71.0
0.960	75	339	6	897	31.4	7.7	98.3	7.4	72.6
0.980	29	344	1	943	28.3	3.0	99.7	3.3	73.3
1.000	0	345	0	972	26.2	0.0	100.0	.	73.8

The LOGISTIC Procedure

Data Set: WORK.MIKE
Response Variable: GRD1
Response Levels: 2
Number of Observations: 1317
Link Function: Logit

Response Profile

Ordered Value	GRD1	Count
1	0	972
2	1	345

Stepwise Selection Procedure

Step 0. Intercept entered:

Residual Chi-Square = 232.4299 with 11 DF (p=0.0001)

Step 1. Variable PAY2 entered:

Criteria for Assessing Model Fit

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	1516.803	1423.590	.
SC	1521.986	1433.956	.
-2 LOG L	1514.803	1419.590	95.213 with 1 DF (p=0.0001)
Score	.	.	94.054 with 1 DF (p=0.0001)

Residual Chi-Square = 155.2647 with 10 DF (p=0.0001)

Step 2. Variable BF12 entered:

Criteria for Assessing Model Fit

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	1516.803	1368.892	.
SC	1521.986	1384.441	.
-2 LOG L	1514.803	1362.892	151.911 with 2 DF (p=0.0001)
Score	.	.	148.365 with 2 DF (p=0.0001)

Residual Chi-Square = 103.5543 with 9 DF (p=0.0001)

Step 3. Variable AGE10 entered:

Criteria for Assessing Model Fit

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	1516.803	1323.451	.
SC	1521.986	1344.183	.
-2 LOG L	1514.803	1315.451	199.352 with 3 DF (p=0.0001)
Score	.	.	182.205 with 3 DF (p=0.0001)

Residual Chi-Square = 63.1606 with 8 DF (p=0.0001)

Step 4. Variable EAOS5 entered:

Criteria for Assessing Model Fit

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	1516.803	1294.505	.
SC	1521.986	1320.421	.
-2 LOG L	1514.803	1284.505	230.298 with 4 DF (p=0.0001)
Score	.	.	205.159 with 4 DF (p=0.0001)

Residual Chi-Square = 34.75[illegible]1 with 7 DF (p=0.0001)

Step 5. Variable MC9 entered:

Criteria for Assessing Model Fit

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	1516.803	1282.876	.
SC	1521.986	1313.975	.
-2 LOG L	1514.803	1270.876	243.927 with 5 DF (p=0.0001)
Score	.	.	216.078 with 5 DF (p=0.0001)

Residual Chi-Square = 21.4121 with 6 DF (p=0.0015)

Step 6. Variable MAR11 entered:

Criteria for Assessing Model Fit

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	1516.803	1276.620	.
SC	1521.986	1312.902	.

-2 LOG L	1514.803	1262.620	252.183 with 6 DF (p=0.0001)
Score	.	.	221.277 with 6 DF (p=0.0001)

Residual Chi-Square = 13.5043 with 5 DF (p=0.0191)

Step 7. Variable DIVE4 entered:

Criteria for Assessing Model Fit

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	1516.803	1272.066	.
SC	1521.986	1313.531	.
-2 LOG L	1514.803	1256.066	258.737 with 7 DF (p=0.0001)
Score	.	.	226.359 with 7 DF (p=0.0001)

Residual Chi-Square = 6.8256 with 4 DF (p=0.1454)

Step 8. Variable RES3 entered:

Criteria for Assessing Model Fit

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	1516.803	1270.061	.
SC	1521.986	1316.709	.
-2 LOG L	1514.803	1252.061	262.742 with 8 DF (p=0.0001)
Score	.	.	229.581 with 8 DF (p=0.0001)

Residual Chi-Square = 2.2392 with 3 DF (p=0.5243)

NOTE: No (additional) variables met the 0.05 significance level for entry into the model.

Summary of Stepwise Procedure

Step	Variable Entered	Variable Removed	Number In	Score Chi-Square	Wald Chi-Square	Pr > Chi-Square
1	PAY2		1	94.0538	.	0.0001
2	BF12		2	57.3456	.	0.0001
3	AGE10		3	43.3563	.	0.0001
4	EAOS5		4	29.8638	.	0.0001
5	MC9		5	13.1795	.	0.0003
6	MAR11		6	7.9374	.	0.0048
7	DIVE4		7	6.5292	.	0.0106
8	RES3		8	4.5943	.	0.0321

Analysis of Maximum Likelihc : Estimates

Parameter Standard Wald Pr > Standardized Odds

Variable	DF	Estimate	Error	Chi-Square	Chi-Square	Estimate	Ratio
INTERCPT	1	2.6360	1.1113	5.6269	0.0177	.	13.957
PAY2	1	-1.0876	0.0894	148.1239	0.0001	-0.707657	0.337
RES3	1	1.0230	0.4922	4.3196	0.0377	0.073910	2.782
DIVE4	1	0.4076	0.1668	5.9745	0.0145	0.109933	1.503
EAOS5	1	-0.4814	0.0799	36.2969	0.0001	-0.304286	0.618
MC9	1	-0.0410	0.0117	12.2188	0.0005	-0.143417	0.960
AGE10	1	0.1762	0.0333	28.0075	0.0001	0.278160	1.193
MAR11	1	-0.5986	0.2112	8.0353	0.0046	-0.124922	0.550
BF12	1	0.1219	0.0202	36.3846	0.0001	0.236532	1.130

Association of Predicted Probabilities and Observed Responses

Concordant	= 77.7%	Somers' D	= 0.557
Discordant	= 22.0%	Gamma	= 0.559
Tied	= 0.2%	Tau-a	= 0.216
(335340 pairs)		c	= 0.779

Classification Table

	Correct		Incorrect		Percentages				
Prob Level	Event	Non-Event	Event	Non-Event	Correct	Sensi-tivity	Speci-ficity	False POS	False NEG
0.080	972	0	345	0	73.8	100.0	0.0	26.2	.
0.100	972	2	343	0	74.0	100.0	0.6	26.1	0.0
0.120	972	3	342	0	74.0	100.0	0.9	26.0	0.0
0.140	971	6	339	1	74.2	99.9	1.7	25.9	14.3
0.160	971	9	336	1	74.4	99.9	2.6	25.7	10.0
0.180	971	14	331	1	74.8	99.9	4.1	25.4	6.7
0.200	968	17	328	4	74.8	99.6	4.9	25.3	19.0
0.220	967	20	325	5	74.9	99.5	5.8	25.2	20.0
0.240	967	23	322	5	75.2	99.5	6.7	25.0	17.9
0.260	965	23	322	7	75.0	99.3	6.7	25.0	23.3
0.280	962	24	321	10	74.9	99.0	7.0	25.0	29.4
0.300	961	26	319	11	74.9	98.9	7.5	24.9	29.7
0.320	959	31	314	13	75.2	98.7	9.0	24.7	29.5
0.340	956	35	310	16	75.2	98.4	10.1	24.5	31.4
0.360	951	44	301	21	75.6	97.8	12.8	24.0	32.3
0.380	949	54	291	23	76.2	97.6	15.7	23.5	29.9
0.400	945	62	283	27	76.5	97.2	18.0	23.0	30.3
0.420	940	70	275	32	76.7	96.7	20.3	22.6	31.4
0.440	932	77	268	40	76.6	95.9	22.3	22.3	34.2
0.460	924	89	256	48	76.9	95.1	25.8	21.7	35.0
0.480	915	99	246	57	77.0	94.1	28.7	21.2	36.5
0.500	906	115	230	66	77.5	93.2	33.3	20.2	36.5
0.520	891	123	222	81	77.0	91.7	35.7	19.9	39.7
0.540	872	140	205	100	76.8	89.7	40.6	19.0	41.7
0.560	863	152	193	109	77.1	88.8	44.1	18.3	41.8
0.580	849	165	180	123	77.0	87.3	47.8	17.5	42.7
0.600	835	176	169	137	76.8	85.9	51.0	16.8	43.8
0.620	817	188	157	155	76.3	84.1	54.5	16.1	45.2
0.640	799	198	147	173	75.7	82.2	57.4	15.5	46.6

0.660	785	206	139	187	75.2	80.8	59.7	15.0	47.6
0.680	764	215	130	208	74.3	78.6	62.3	14.5	49.2
0.700	[illegible]35	225	120	237	72.9	75.6	65.2	14.0	51.3
0.720	[illegible]12	234	111	260	71.8	73.3	67.8	13.5	52.6
0.740	[illegible]3	243	102	289	70.3	70.3	70.4	13.0	54.3
0.760	[illegible]51	255	90	321	68.8	67.0	73.9	12.1	55.7
0.780	613	267	78	359	66.8	63.1	77.4	11.3	57.3
0.800	570	273	72	402	64.0	58.6	79.1	11.2	59.6
0.820	520	286	59	452	61.2	53.5	82.9	10.2	61.2
0.840	475	298	47	497	58.7	48.9	86.4	9.0	62.5
0.860	406	310	35	566	54.4	41.8	89.9	7.9	64.6
0.880	338	314	31	634	49.5	34.8	91.0	8.4	66.9
0.900	271	320	25	701	44.9	27.9	92.8	8.4	68.7
0.920	213	331	14	759	41.3	21.9	95.9	6.2	69.6
0.940	146	336	9	826	36.6	15.0	97.4	5.8	71.1
0.960	75	339	6	897	31.4	7.7	98.3	7.4	72.6
0.980	29	344	1	943	28.3	3.0	99.7	3.3	73.3
1.000	0	345	0	972	26.2	0.0	100.0	.	73.8

APPENDIX E

ANALYSIS OF GAMMA DISTRIBUTION FIT FOR TRANSFER DATA

DATA : X
SELECTION : ALL
X AXIS LABEL : X
SAMPLE SIZE : 363
CENSORING : NONE
FREQUENCIES : 1
EST. METHOD : MAXIMUM LIKELIHOOD
CONF METHOD : ASYMPTOTIC NORMAL APPROXIMATION

	CONF. INTERVALS (95 PERCENT)			COVARIANCE MATRIX OF PARAMETER ESTIMATES	
PARAMETER	ESTIMATE	LOWER	UPPER	ALPHA	BETA
ALPHA	1.9056	1.6488	2.1623	0.017151	-0.24864
BETA	27.624	23.371	31.877	-0.24864	4.7075

LOG LIKELIHOOD FUNCTION AT MLE = -2127.8

	SAMPLE	FITTED
MEAN	: 52.639	52.639
STD DEV	: 52.396	38.133
SKEWNESS	: 3.6681	1.4488
KURTOSIS	: 23.53	6.1487

* BASED ON MIDPOINTS OF FINITE INTERVALS

PERCENTILES	SAMPLE	FITTED
5:	16	8.7853
10:	18	13.356
25:	25	24.649
50:	36	43.773
75:	56	71.096
90:	113	103.55
95:	149	126.79

GOODNESS OF FIT TESTS

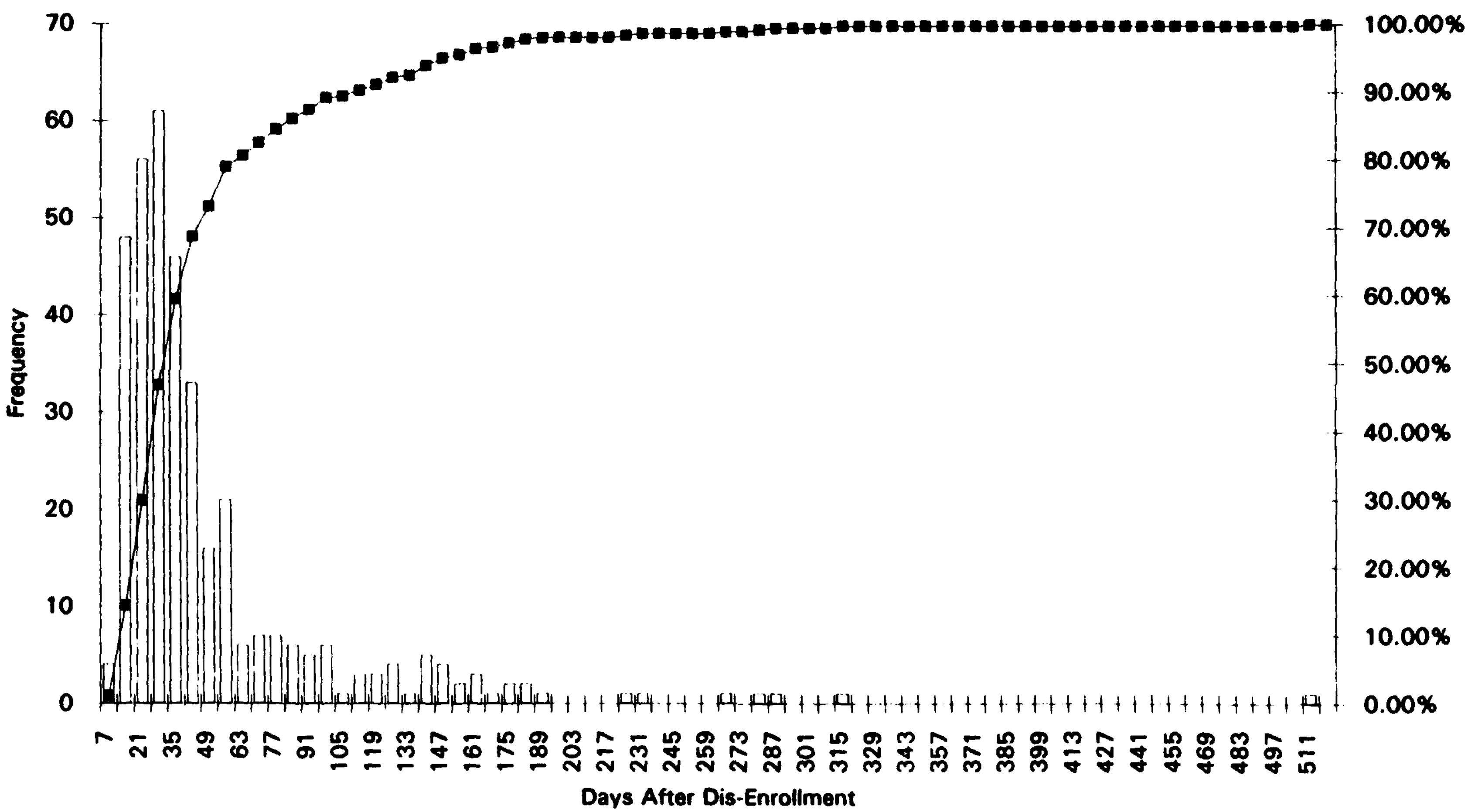
CHI-SQUARE : 47.369
DEG FREED: 1
SIGNIF : 5.8799E?12
KOLM-SMIRN : 0.14695
SIGNIF : 3.1089E?7
CRAMER-V M : 2.3829
SIGNIF : < .01
ANDER-DARL : 12.91
SIGNIF : < .01

KS, AD, AND CV SIGNIF. LEVELS NOT EXACT WITH ESTIMATED PARAMETERS.

NOTE: A SMALL SIGNIFICANCE LEVEL (EG. P?.01) INDICATES LACK OF FIT

CHI-SQUARE GOODNESS OF FIT TABLE

LOWER	UPPER	OBS	EXP	O-E	((O-E)*2)?E
INF.	51.1	259	210.77	48.23	11.036
51.1	102.2	65	114.47	-49.467	21.377
102.2	153.3	21	29.736	-8.7355	2.5663
153.3	+INF.	18	8.0274	9.9726	12.389
TOTAL		363	363		47.369



Histogram Time To Transfer After Dis-Enrollment

APPENDIX F

Days (i)	#GRD g(i)	Cost [L(i)]	AC[L(i)]	Savings [L(i)]	PS[L(i)]	MC[L(i)]
14	3	32,259.66	10,753.22	3,135,229.19	1	2,014.12
21	25	76,570.34	3,062.81	3,090,918.51	0.99	3,259.62
28	46	145,022.45	3,152.66	3,022,466.4	0.96	3,155.3
35	76	239,681.59	3,153.71	2,927,807.26	0.93	3,498.67
42	108	351,639.16	3,255.92	2,815,849.69	0.9	5,579.7
49	142	541,348.83	3,812.32	2,626,140.02	0.84	5,123.97
56	209	884,655.03	4,232.8	2,282,833.81	0.73	6,159.3
63	253	1,155,664.23	4,567.84	2,011,824.62	0.64	6,737.98
70	306	1,512,777.3	4,943.72	1,654,711.55	0.53	6,906.42
77	344	1,775,221.36	5,160.53	1,392,267.49	0.44	11,204.25
84	360	1,954,489.35	5,429.14	1,212,999.49	0.39	8,609.89
91	386	2,178,346.57	5,643.38	989,142.28	0.32	20,811.46
98	391	2,282,403.87	5,837.35	885,084.98	0.28	27,300.14
105	397	2,446,204.69	6,161.72	721,284.15	0.23	21,876.18
112	404	2,599,337.97	6,434	568,150.88	0.18	14,107.71
119	409	2,669,876.52	6,527.82	497,612.33	0.16	12,307.68
126	415	2,743,722.57	6,611.38	423,766.28	0.14	20,203.17
133	418	2,804,332.07	6,708.93	363,156.78	0.12	95,411.79
140	419	2,899,743.86	6,920.63	267,744.99	0.09	95,411.79
147	419	2,942,147.67	7,021.83	225,341.18	0.07	95,411.79
154	419	2,974,524.65	7,099.1	192,964.2	0.06	95,411.79
161	419	3,005,194.85	7,172.3	162,294	0.05	95,411.79
168	419	3,015,206.04	7,196.2	152,282.81	0.05	95,411.79
175	419	3,022,563.24	7,213.75	144,925.61	0.05	37,386.52
182	420	3,059,949.76	7,285.59	107,539.09	0.03	37,386.52
189	420	3,073,572.01	7,318.03	93,916.84	0.03	37,386.52
196	420	3,073,572.01	7,318.03	93,916.84	0.03	37,386.52
203	420	3,073,572.01	7,318.03	93,916.84	0.03	37,386.52
210	420	3,079,846.82	7,332.97	87,642.03	0.03	37,386.52
217	420	3,079,846.82	7,332.97	87,642.03	0.03	37,386.52
224	420	3,086,834.88	7,349.61	80,653.97	0.03	37,386.52
231	420	3,086,834.88	7,349.61	80,653.97	0.03	37,386.52
238	420	3,094,134.91	7,366.99	73,353.94	0.02	37,386.52
245	420	3,101,340.44	7,384.14	66,148.41	0.02	37,386.52

Days (i)	#GRD g(i)	Cost [L(i)]	AC[L(i)]	Savings [L(i)]	PS[L(i)]	MC[L(i)]
252	420	3,110,084	7,404.96	57,404.85	0.02	37,386.52
259	420	3,110,084	7,404.96	57,404.85	0.02	37,386.52
266	420	3,117,980.05	7,423.76	49,508.8	0.02	37,386.52
273	420	3,117,980.05	7,423.76	49,508.8	0.02	37,386.52
280	420	3,129,734.65	7,451.75	37,754.2	0.01	37,386.52
287	420	3,129,734.65	7,451.75	37,754.2	0.01	10,177.51
294	421	3,139,912.16	7,458.22	27,576.69	0.01	10,177.51
301	421	3,139,912.16	7,458.22	27,576.69	0.01	10,177.51
308	421	3,139,912.16	7,458.22	27,576.69	0.01	10,177.51
315	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
322	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
329	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
336	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
343	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
350	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
357	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
364	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
371	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
378	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
385	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
392	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
399	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
406	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
413	421	3,149,645.53	7,481.34	17,843.32	0.01	10,177.51
420	421	3,149,645.53	7,481.34	17,843.32	0.01	17,843.32
427	422	3,167,488.85	7,505.9	0	0	7,505.9

APPENDIX G

Days (i)	# GRD g(i)	Cost[L(i)]	P{L< =l| GRD}	PS[L(i)]
150	0	915,444.23	0	0.81
170	34	1,223,883.77	0.08	0.74
190	244	2,783,771.58	0.58	0.41
210	252	2,882,639.76	0.6	0.39
230	308	3,393,002.47	0.73	0.29
250	351	3,822,430.91	0.83	0.19
270	354	3,906,475.9	0.84	0.18
290	373	4,147,278.61	0.88	0.13
310	390	4,326,021.25	0.92	0.09
330	390	4,326,021.25	0.92	0.09
350	402	4,458,463.56	0.95	0.06
370	406	4,514,278.08	0.96	0.05
390	413	4,601,520.42	0.98	0.03
410	417	4,653,358.31	0.99	0.02
430	417	4,653,358.31	0.99	0.02
450	419	4,684,205.6	0.99	0.01
470	421	4,719,615.4	1	0.01
490	421	4,719,615.4	1	0.01
510	421	4,719,615.4	1	0.01
530	422	4,746,757.01	1	0

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Interview between K. E. Jansen, BM1 (DV PJ), USN, NMPC (Code 401), Washington, DC, and the author, 20 September 1993.

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